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Achieving Self-Sufficiency Through Sugar Supply And Demand Policies (Dynamics System Approach)

Duwi Yunitasari

Abstract: In 2010 to 2016, Indonesia imported white crystal sugar (WCS) to fulfill the household consumption. The objectives of this research are to: 1) examine the possibility of achieving self-sufficiency of WCS without the policy of National Sugar Industry Revitalization (NSIR), 2) analyze the impact of NSIR policy on the achievement of national sugar self-sufficiency, and 3) formulate an alternative policy of WCS production. This study used primary and secondary data. The primary data collection was conducted by interviewing the respondents, including sugar cane farmers, representatives from the Center for Sugar Research and Development (P3GI), National Plantation Company (PTPN) XI, Indonesian Ministry of Agriculture, as well as from the sugar factory representatives. Secondary data were taken from related institutions, i.e., Indonesia's Central Bureau of Statistics (BPS), sugar factory, and Indonesian Ministry of Agriculture. The modeling simulation is conducted using Powersim studio software to analyze national sugar industry from 2010 to 2025. The analysis period is based on the implementation year of the NSIR policy. The model behavior in actual condition indicates that national self-sufficiency is not achieved without the implementation of NSIR policy as indicated by the negative supply of WCS during the simulation period. Therefore, a joint NSIR policy is required to achieve national self-sufficiency. Applying 8 (eight) policy scenarios, results of the research show that: 1) in partial, the scenario of NSIR policy fails to support the achievement of national sugar self-sufficiency, 2) policy simulation of scenario 5 (demand side), i.e., the reduction of WCS consumption can make Indonesia achieves national sugar self-sufficiency, and 3) simultaneous NSIR policy on scenario 4 (supply side), i.e., the land expansion, productivity, and sugar yield, can make Indonesia achieves national sugar self-sufficiency.

Keywords: Self-sufficiency of WCS, NSIR, Dynamics System, Scenarios, Existing Condition, Sugarcane, Suppy and Demand policies

INTRODUCTION

According to Decree of Indonesian Minister of Industry and Trade number 115/MPP/KEP/2/1998, sugar is one of strategic commodities. Sugar is an essential comestible for Indonesian people and the government is obliged to provide sufficient sugar, both in term of quantity and quality. Indonesia once experienced the heyday as the world's largest sugar exporting country (in the 1930s), after 1930s Indonesian sugar industry's performance was gradually declined that finally positioning Indonesia as one of the major sugar importers (Susilohadi et al., 2012; Sharif et al., 2009). Indonesian Sugar Association data (2011) show an increase in refined sugar import rate of 29.49 percent per year during 2005-2010. Brazil is one of the largest sugar exporting countries (Bordonal et al. 2018, UNICA, 2009). In terms of demand, sugar consumption is differentiated into two types, the white crystal sugar (WCS) for direct consumption, and the refined crystal sugar (RCS) for industrial consumption (Asmarantaka, 2012; Ginandjar, 2012; Zaini et al., 2012, Yunitasari, 2015). Referring to Indonesia's Central Bureau of Statistics (BPS) data (2016), the sugar import is increasing every year. In 2010-2016, to fulfill WCS consumption, Indonesian government had to import sugar. In 2015, the population of Indonesia was 255,461 million people and by 2020, it is predicted that the number will increase to 271,066 million. The population is predicted to be significantly increased in 2025 (BPS, 2017). The increase in population will lead to an increase in sugar consumption. If the increase in sugar consumption is not accompanied by the increase in production, the sugar factory will be failed to achieve the target of producing sugar to fulfill national consumption (Keerthipala, 2002).

- *Duwi Yunitasari*
- *Faculty of Economics and Business, University of Jember*
- *Email: duwiyunita.feb@unej.ac.id*

An increase in demand that is not in line with the increase in production will threaten the national sugar industry because imported sugar will outperform domestic sugar with a lower quality (Asmarantaka et al., 2012). In the next 5 (five) years (2014 ~ 2019), WCS production growth is predicted to reach 2.50% per year, while WCS consumption is 4.03% per year, and the deficit is 5.95% per year (Indonesian Ministry of Trade, 2014). The increase in population will lead to an increase in sugar consumption. If the increase in sugar consumption is not accompanied by the increase in production, the sugar factory will be failed to achieve the target of producing sugar to fulfill national consumption (Keerthipala, 2002). An increase in demand that is not in line with the increase in production will threaten the national sugar industry because imported sugar will outperform domestic sugar with a lower quality (Asmarantaka et al., 2012). In the next 5 (five) years (2014 ~ 2019), WCS production growth is predicted to reach 2.50% per year, while WCS consumption is 4.03% per year, and the deficit is 5.95% per year (Indonesian Ministry of Trade, 2014). Serious effort are needed to reduce the import dependency of WCS to realize the WCS self-sufficiency. Goverment launced the National Sugar Industry Revitalization program. The achievement of WCS self-sufficiency in the future is influenced by the factors related to the availability of raw materials, sugar processing, and sugar trade and demand, either independently or as the result of interaction between these factors. These factors will shape the behavior of the national WCS industry system. Referring to previous arguments, the objectives of this research are: (1) examining the possibility of achieving self-sufficiency WCS without the policy of National Sugar Industry Revitalization (NSIR), (2) analyzing the impact of NSIR policy on the achievement of the national sugar self-sufficiency, and (3) formulating an alternative policy of WCS production. Supply and demand side policies.

LITERATURE REVIEW

According to the Indonesian Sugar Council (2009), a general understanding of self-sufficiency for a product in a country will be achieved if the number of domestic products is at least 90 percent of the total domestic consumption, both to meet household, industrial and national trade balance. Thus, the notion of sugar self-sufficiency is the production of domestic sugar cane-based sugar which has reached 90 percent of national sugar needs.

METHOD

This research is a national macro-level analysis. Using a dynamic system. It applied survey method, research data were collected from primary and secondary sources. The primary data was collected by interviewing respondents, i.e., sugar cane farmers, representatives from the Center for Research and Sugar Development (P3GI), National Plantation Company (PTPN) XI, Indonesian Ministry of Agriculture, as well as from the sugar factories in Indonesia. Secondary data were taken from relevant institutions which include Indonesia's Central Bureau of Statistics (BPS), sugar factory, and Indonesian Ministry of Agriculture. The research objectives are answered through four stages, these include: building national sugar availability model, validation, simulation, and execution of alternative scenarios towards model, which in this case is conducted by using Powersim studio software. Modeling simulations were conducted to analyze national sugar industry from 2010 to 2025. The analysis period was based on the year of the NSIR. The research stages are described as follows:

1. Needs Analysis

Table 1 *The analysis of stakeholder's needs in national WCS model*

Stakeholder	Stakeholder's Needs
Government	1. The increase of sugar yield
	2. Substitution of WCS consumption
	3. Increased production of sugar cane and sugar
	4. Availability of WCS
	5. NSIR runs based on target
	6. Self-sufficiency WCS
Private Sector	1. High price of sugar
	2. High productivity of sugar cane
	3. High production of sugar
	4. Factory efficiency
	5. Availability of sugar cane material
Consumer	1. Low price of sugar
	2. Increased sugar stock
Farmer	1. High price of sugar
	2. Limitation on imported sugar
	3. High sugar yield
	4. Ease of credit
	5. Fast selling sugar

Source: *Results of interview with the farmers, sugar factory employees, and literature review*

Table 1 shows the difference of needs among stakeholders. This difference of needs indicates the difference of interests and goals among stakeholders. Therefore, the mapping of the various interests of stakeholders is needed in order to achieve sugar self-sufficiency, which is the main aim of this research.

2. Model Structure

In this research, the WCS self-sufficiency model is divided into four sub-models, namely production sub-model, price sub-model, sugar import sub-model, and sugar supply sub-model. The model structure in Figure 1 describes the national sugar self-sufficiency model. Sugarcane production is supported by the availability of land and sugarcane productivity in the Java island, as well as outside of the Java island. WCS is produced from the sugar yield and shrinkage during the production process. The demand side is generated from the consumption of WCS per capita and the population of Indonesia. While the supply side is a determinant of WCS production and WCS stocks. Import of sugar from the imported sugar price, domestic sugar price, and per capita consumption of WCS. The surplus condition or the self-sufficiency of WCS is achieved if supply is larger than demand, and vice versa, the deficit condition is when supply is less than demand.

3. Model Validation

This research uses Mean Absolute Percentage Error (MAPE) statistical test with the following mathematical formula:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{\left|Y_t - \hat{Y}_t\right|}{Y_t}$$

Where:

$\hat{Y}t$ = actual data value
Yt = model simulation value
n = year/time interval

The criteria of model accuracy with MAPE test are as follows (Lomauro and Bakshi, 1985 in Utami, 2006):

MAPE < 5 % : very accurate
5 % < MAPE < 10 % : accurate
MAPE >10 % : not accurate

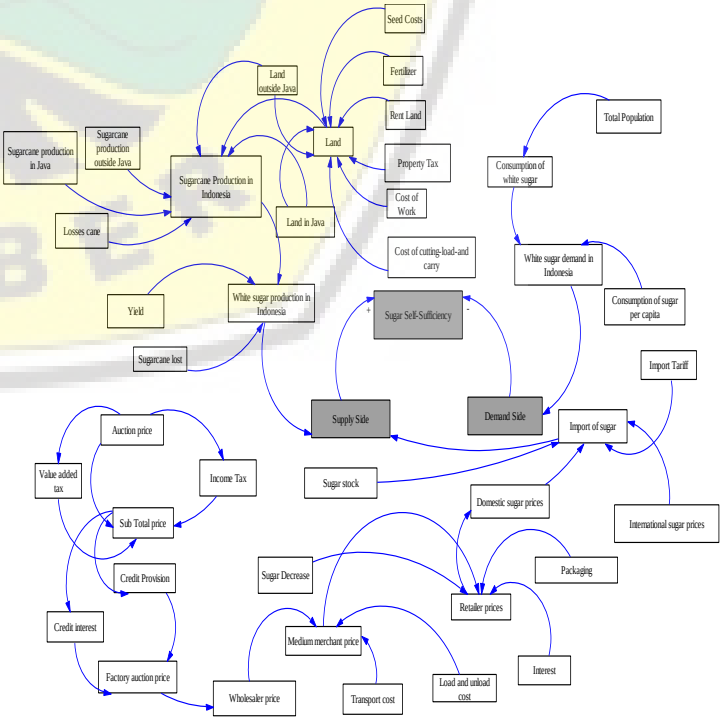

Figure 1. *National Sugar Availability Model (Self-sufficiency)*

4. Model Simulation

The NSIR policy simulations used in this study are based on the following scenarios:

Policy Scenario from the Supply Side (Supply of WCS)

1. Scenario 1: The increase of national sugar cane plantation area was 3.2 percent per year (target of NSIR 2015) to 8 percent per year (target of NSIR 2017).
2. Scenario 2: The increase of national sugar cane plantation productivity was 1.6 percent per year (target of NSIR 2015).
3. Scenario 3: The increase of sugar yield by 1.41 percent per year (target of NSIR 2015).
4. Scenario 4 (alternative 1): The combination of scenarios 1, 2, and 3

Policy Scenario from the Demand Side (WCS Needs)

5. Scenario 5: Decrease in WCS Consumption
6. Scenario 6: Decrease in population
7. Scenario 7: Increasing import tariff (import duty) by 40%
8. Scenario 8: Shorten the trading channel and the relevant costs

RESULTS AND DISCUSSION

Results from model validation:

Table 2 *Validation of WCS Production Model 2010-2016*

Criteria	Variables		
	WCS Production	Sugar cane Production	Population
AME	4.06%	5.98	-0.31

Source: *data processed*

The result of MAPE test calculation on WCS production in 2010-2016 is 4.06% (table 2). This means that there is a 4.06% deviation between the simulation results and the actual data. Based on the MAPE model criteria, the result of 4.06% is less than 5%. Thus, it can be concluded that the model is very accurate and acceptable. The result of MAPE test calculation on sugarcane production in 2010-2016 is 5.98%. This means that there is a 5.98% deviation between the simulation results and the actual data. Based on the MAPE model criteria, the result of 5.98% is more than 5% and less than 10%. Thus, it can be concluded that the model is very accurate and acceptable. The calculation result of the MAPE test on Indonesian Population in 2010-2016 is -0.31%. This means that there is a -0.31% deviation between the simulation result and the actual data. Based on the criteria of MAPE model, the result of -0.31% is less than 5%. Thus, it can be concluded that the model is very accurate and acceptable.

Model Behavior

1. The Model of Actual Condition of WCS Self-Sufficiency

The national WCS self-sufficiency modeling is aimed to analyze WCS self-sufficiency referring to the behavior of supply, demands, and availability. It is expected that the availability of WCS is positive, which means that the needs for national sugar can be fulfilled from the supply side (production). The simulation results of the WCS self-sufficiency analysis of the actual condition are presented in Figure 2.

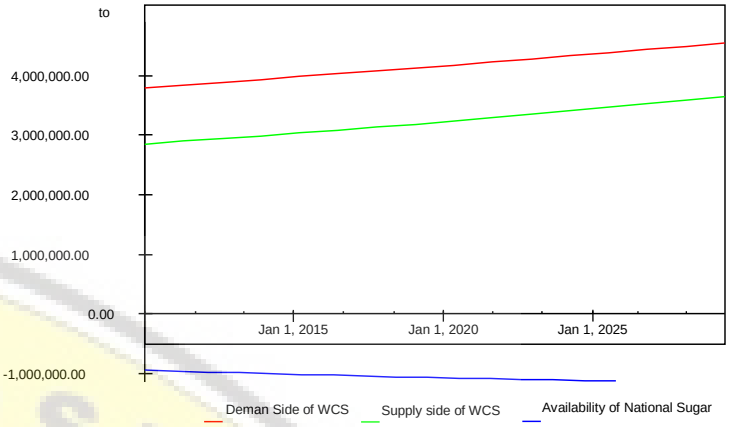

Figure 2. *The availability of national WCS in actual condition, 2010-2025*

Figure 2 shows that the WCS supply graph has an increasing trend with exponential growth pattern. WCS supply growth is sourced from the growth of land area, increased sugar cane productivity in Java island and outside Java island, and the sugar yield. Meanwhile, the demand side of WCS also experienced growth with exponential growth pattern as a result of population growth and growth of WCS per capita consumption. In general, the graph of WCS needs is above the WCS supply graph starting from 2010 to 2025, which is until the end of the simulation period. This means that without NSIR policy, the WCS self-sufficiency will not be achieved until the end of the simulation period. In 2010, the availability of national WCS is deficit 949.151 tons. In the absence of supporting policy, the WCS deficit will increase until the end of the simulation period. The national WCS deficit in 2025 is 1,010 million tons. While in 2016, the national WCS deficit was 986,359 tons.

2. The Impact of NSIR Policy on Achieving WSC Self-Sufficiency

2.1 Policy Scenarios from the Supply Side (Supply of WCS)

Scenario 1 is a NSIR policy scenario for increasing land resources by expanding the land through gradual land forming and reducing the growth of sugar cane conversion. The expansion of sugar cane plantation should be outside the Java island. This is due to the high competition of the land use for other commodities as well as for non-agricultural purposes in Java island. In addition, the land expansion should cooperate with the Forestry Department especially in utilizing unused lands. Outside Java Island, the Ministry of Agriculture begins to optimize the peatlands for sugar cane planting (Indonesian Ministry of Agriculture, 2017). The Road Map of the Increase of Sugar Production Towards National Self-Sufficiency 2016-2045 is a guidance to achieve the target of an acceleration program of increasing national sugar production in creating food sovereignty, especially the fulfillment of national sugar

needs through the existence of industries with high level of competitiveness. In details, the objectives are as follows:

1. Increasing national sugar production by 3.26 million tons in 2019 and self-sufficiency of sugar by 6.10 million tons in 2025.
2. Increasing the competitiveness of the sugar industry through increased efficiency, product quality, and the development of product diversification.

In 2019, sugar production is projected to increase to 3.26 million tons from 3.08 million tons produced by the existing sugar factories and 179 thousand tons produced by the new sugar factory development. It means that in 2019, the targeted WCS production can fulfill the needs of direct consumption of 2.83 million tons (Indonesian Ministry of Agriculture, 2017). However, referring to the results of scenario 1 (Figure 3), the sugar production in 2019 is out of target. According to the simulation result, sugar production in 2019 is 2,799,703 tons. Thus, there is a shortage of about 460,000 tons of WCS. Referring to the simulation in scenario 1 (Figure 3), the WCS production target in 2019 is not achieved. The production of WCS in 2019 is 2,799,703 tons.

Scenario 2: Increasing 1.6% Sugarcane Productivity

Figure 2 shows that the graph from the WCS demand side (needs) continues to increase during the simulation period. While the graph of WCS supply also increases in 2010 to 2025. The 1.6% increase in productivity is not able to create positive availability of WCS. This is shown during the simulation period (2010-2025) indicating the deficit of WCS availability. Results of this study show that the increase sugarcane productivity adds the national WCS supply during the simulation period. In 2010, the WCS supply with scenario 2 was deficit of 949,151 tons and continued to decrease in the following years up to 148,376 tons in 2025. In general, it can be stated that the productivity improvement policy is not sufficient to support Indonesia in achieving self-sufficiency of WCS in 2019.

Scenario 3: The increase of 1.41% sugar yield

One of the efforts to attain the national sugar self-sufficiency in 2025 is by increasing the sugar yield. The advantage of increasing productivity through the sugar yield is eliminating the needs to increase milling capacity and also reducing the costs of freight haul and sugar processing. Figure (2) shows that the WCS demand and supply graph continuously increas during the simulation period. Changes in the supply of national WCS through increas sugar yield have not been able to make the positive supply of WCS from 2010 until the end of the simulation period. In 2010, the availability of WCS with scenario 3 was deficit amounted to 472,555 tons and continued to decrease in the following years up to 139,250 tons in 2025. In general, it can be stated that the policy of increasing the sugar yield by 1.41 percent per year is failed to support the process of achieving national self-sufficiency of WCS in 2025.

Alternative Scenario

Scenario 4 (alternative 1): The combination of scenarios 1, 2, and 3

In the previous simulation, the study has analyzed the impact of NSIR policy on the achievement of national WCS self-sufficiency. The simulated policy is an ongoing policy up to recent time. The next simulation is simulating alternative policy scenarios of achieving self-sufficiency of WCS. In scenarios 1, 2 and 3, when the policy is simulated individually, sugar self-sufficiency has not achieved yet. Thus, the analysis is conducted by combining the alternative scenarios 1, 2, and 3 simultaneously. In the scenarios 1, 2, and 3 as shown in Figure 3, the availability of WCS is in surplus in 2022 (number 13 in figure 3). In 2010 (show with number 1 in figure 3), the deficit was 768,374 tons and in 2022, the surplus would be 81,806 tons. To maintain the quantity of sugar cane farmers and the quality of sugar cane, the implemented policy is directed to benefit the farmers in the planting process and also in making agreement and transaction among sugar traders (Nelson and Panggabean, 2011; Donald, 2004). The width of the sugar cane plantation area is one of the most efficient forecast variables that can be used to predict plantation areas and its result with a reasonable degree of accuracy in the future (Masoood and Javed, 2004).

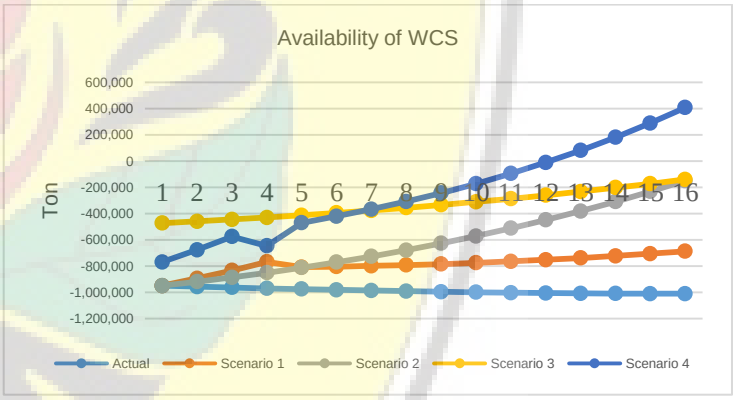

Figure 3 *National WCS availability in actual, scenario 1, 2, 3, and 4, 2010-2025*

2.2 Demand Policy Scenario (WCS Needs)

Scenario 5 (alternative 2): Decrease on WCS Consumption

In scenario 2, the decrease of WCS consumption is 33%. The consumption of WCS becomes 12 kg/year (early consumption was 16 kg WCS per capita). By simulating the scenario of consumption reduction policy, it is expected that the self-sufficiency can be achieved in 2022. The supply of WCS in 2022 will experience a surplus of 777.61 tons that can be realized by providing sugar with special packaging as widely produced by the sugar industry. If Indonesian people consume the packaged sugar produced by the industry, then the sugar availability for the household can be fulfilled by WCS.

Scenario 6 (alternative 3): Decrease in population

Figure 4 shows that demand and supply of WCS are continually increasing during the simulation period. The policy of decreasing population growth makes the WCS supply positive by 2030 (the simulation period is extended to 5 years). In 2010, referring to alternative scenario 3, the WCS supply experienced a deficit of 949,151 tons and continued to increase in the following year. It is expected to have a surplus of 57.362 tons in 2030. Alternative scenario 3: decrease in population growth will make Indonesia achieve WCS self-sufficiency by 2030.

Scenario 7 (alternative 4): Increasing import tariff (import duty) by 40%

It is recorded in 2025 that the deficit of sugar availability is 310,104 tons, compared to 2022 when the deficit is (minus) 335,370 tons. However, the increased import tariff has not been able to achieve the sugar surplus by 2025. Scenario 8 (alternative 5): Shorten the trade channel and reducing the costs Referring to the dynamics model of the research, the sugar cane trade channels are passing several stages, i.e., determining the auction price in the factory, wholesalers, intermediate traders, retailers, and lastly the price of sugar in the market. Similarly, the costs spent during the trading process are consisting of loading and unloading costs, shrinkage, bank interest, freight charges, packaging, credit interest, and credit provision. Referring to scenario 8, shortening the trade channels since the auction activity in the factory will directly form the market price (derived from the auction). Similarly, the costs incurred during the trade process are eliminated. Apparently, cutting the trade channels and reducing the costs incurred during the trading process did not make Indonesia achieving the national self-sufficiency as shown in Figure 4.

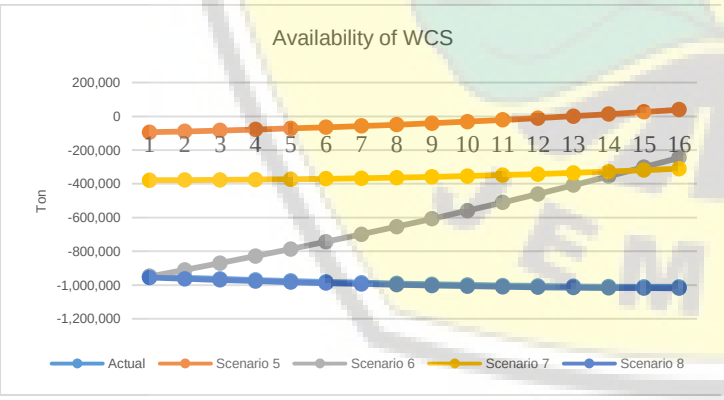

Figure 4 *Availability of national WCS in actual, scenario 5, 6, 7, and 8 in 2010-2025*

Comparison between the Actual Condition and Scenario on Supply and Demand Sides

The simulation results from the previous various scenarios can be compared to each other to formulate the best policy in achieving self-sufficiency of WCS. In this analysis, the comparison is between the availability of WCS in the actual condition with the policy scenario to obtain the best alternative policy. According to the simulation as shown in Figure 2, the model performance of the actual condition shows that WCS self-sufficiency is not achieved. This is indicated by the negative WCS availability graph during the simulation period. Therefore, the government should create a policy related to the supply and needs of WCS in order to increase the availability of WCS. Figure 3 shows that Scenario 4, which is the combination of scenarios 1, 2, and 3, has a better performance compared to the other alternative policy scenarios. The simulation results also show that scenario 5, which is the scenario of reducing WCS consumption, can make Indonesia achieves the national self-sufficiency of WCS. This scenario manages to make Indonesia achieve self-sufficiency of WCS in 2022 until the end of the simulation period. The achievement of self-sufficiency and food security in the sugar industry can improve rural life and provide sustainable livelihoods for millions of people (Mbalwa et al., 2014).

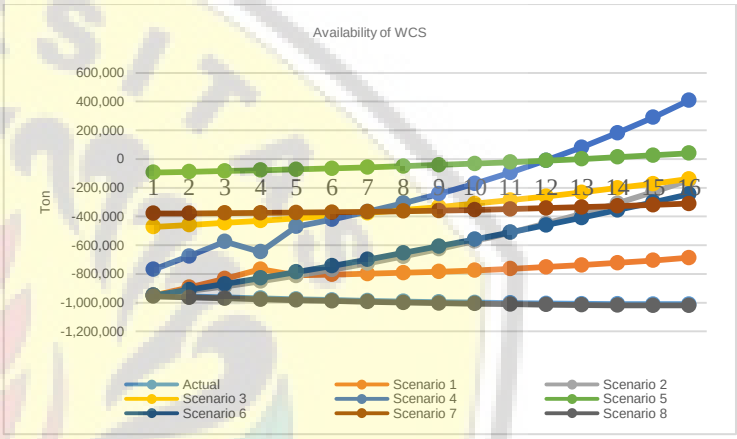

Figure 5 *Comparison of WCS availability in various scenarios of self-sufficiency.*

In future should pay attention to the microlevel, especially to farmers' decision-making process and their impacts on sugarcane expansion, because the largest land area is owned by the smallhalder of sugar cane farmers (Granco et al. 2017). Adoption of innovative technologies indicates that improvements in both agricultural and industrial sectors have led to a better sustainability and revenue of sugarcane (Bordonal et al. 2018). Sugar production is depended on sufficient cane yield which also needs a high-tech management (Hamdi, 2016)

CONCLUSION

Referring to the research results, the conclusions are as follows:

1. Model behavior on actual condition indicates that WCS self-sufficiency will not be achieved without the NSIR policy. This is indicated by the negative WCS availability during the simulation period. Therefore, a joint NSIR policy is needed in order to achieve national self-sufficiency of WCS.
2. In partial, the NSIR policy scenario failed to achieve National Sugar Self-Sufficiency in Indonesia.
3. The policy simulation through scenarios 4 and 5 can make Indonesia achieves national self-sufficiency of WCS.

RECOMENDATION

This research suggests the followings:

1. Based on the National Sugar Industry Revitalization program, sugar production from the existing sugar factories comes from the areas that are projected to increase by 8% from 446 thousand hectares in 2016 to 511 thousand hectares in 2019. However, this target is quite difficult to achieve considering the rapid growth of population and the massive conversion of sugar plantation area. Thus, the government should support the sugar cane farmers to produce high quality sugar with high sugar yield.
2. Government should create policies that benefit sugar cane farmers in terms of planting costs and selling prices.
3. Sugar industries producing RCS should also support the government policy and participate in providing high quality sugar with affordable price.

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