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THE IMPACT OF THE SUGAR-REVITALIZATION POLICY IN EAST JAVA, INDONESIA: A DYNAMIC-SYSTEM APPROACH

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Abstract. East Java is the largest producer of sugarcane (sugar-producing plants) in Indonesia. However, the achievement target of sugar production and bioethanol has not been reached. This research aims to analyze the policy of revitalizing the national sugar industry toward the achievement of sugar production and the development of bioethanol as a renewable source of energy. The study uses secondary data and analyzed them using the dynamic system.

The findings demonstrate the fact that the policy of revitalizing the national sugar industry managed to increase bioethanol and sugar production. Further, it is evidenced that the economic condition of East Java increased, particularly during scenario 3 (increase of rendement) of 5.4%. The rendement increase of sugarcane is expected to support the national self-supporting sugar production and increase bioethanol production as a renewable energy.

Keywords: bioethanol development, sugar-production achievement, regional economy, and dynamic system

INTRODUCTION

Based on the blueprint of National Energy Management covering 2005–2025, it is estimated that Indonesia's oil reserve, which is 9 billion barrels, with a production level of 500 barrels per year, would surcease in 18 years' time. Moreover, gas reserves are estimated to run out in 61 years; meanwhile, coal reserves, which are worth 19.3 billion, will be depleted in 147 years with its 130-million-ton production (Saputra, 2011). Fossil fuels will be scarce and finally run out, and all countries should manage to find other energy sources and renewable energy (Kementrian Pertanian, 2013). Progressive action is required to reduce the dependency on fuel energy and industrial raw materials from unrenewable and biological sources. A study by Toharisman and Kurniawan (2012) revealed that sugarcane is a large biomass source diffused in all its plants' parts. Once sugarcanes are harvested, only less than 50% of its parts are transported to sugar mills. Those sugarcanes contain sugar and bioethanol.

One of the attempts to reduce the dependency is sugarcane utilization. Sugarcanes, or crops producing sugar, have derivative products such as the shoots, bagasses, molasses, fertilizers, and sugarcane wastes (Kurniawan, 2012). Molasses produced by sugar mills, when processed, can produce bioethanol as a fuel mixture for motorcycles (Yunitasari dan Hakim, 2015; Gunatilake et al., 2014). In the future, ethanol use as a fuel mixture will be able to reduce the cost and fuel subsidy in Indonesia, which tends to increase continually (Kementerian Pertanian, 2013). Furthermore, sugarcane supplies, as the main materials of sugar, are expected to be continually available to meet Indonesians' necessities. Sugar plays an important role as it is considered as one of the basic needs (Tarimo dan Takamura, 1998). Sugarcane also provides employments (Yunitasari, 2015) and increase farmers' income, which then contributes to the gross domestic product through bioethanol processing (Silalertruksa et al, 2011).

Indonesia was the largest sugar exporter in the world in 1930, with its largest sugar production. An integrated cropping system resulted in the largest production in Indonesian history, with 17.43–17.63 ton/hectare (Simatupang et al., 1990). Since 1999, the Indonesian government has attempted to be nationally sugar self-sufficient. To encourage the national sugar production, the government issued the National Sugar Industry Revitalization Policy. The policy aimed at increasing sugar production by increasing land areas, sugar mills' machine restoration, fertiiizer subsidy and credit for the farmers, and increasing ethanol production from sugarcane mollases.

The data in figure 1 show that sugar production fluctuates from year to year. However, sugar production still was not able to fulfill the need for sugar consumption. As a consequence, the government imported sugar from Thailand, India, and Brazil from 2005–2013.

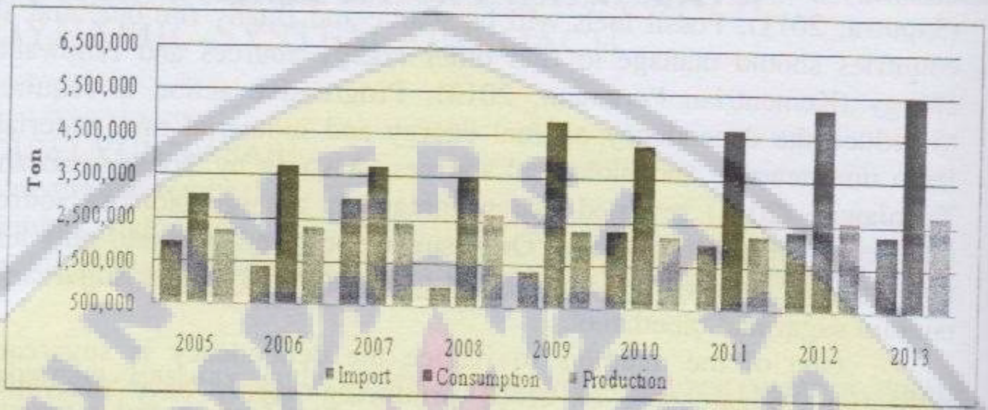

Figure 1. Data of Production, Consumption, and Sugar Import in Indonesia
Source: Dewan Gula Indonesia (Indonesian Sugar Board, 2014)

Being in the 10th in rank among sugar-producing countries in the world, Indonesia cannot be separated from the contribution of sugar-producing areas. One of the largest contributors is East Java Province. In 2011, East Java contributed 49.22% of the total Indonesian sugarcane production (Statistik Tebu Indonesia [Indonesian Sugarcane Statistics], 2011). Figure 2 shows that East Java sugarcane production tends to increase from year to year. During the period of 2009 to 2013, the largest sugarcane production was reached in 2013 with 17.539.485 ton, increasing as much as 12.60%. During this period, the average increase of sugarcane production is 5.19% per year. The small holders' sugarcane increased an average of 25.5% per year. Thus, the increase in sugarcane production in 2013 was contributed by the small holders' sugarcane, which is as much as 15.858.830 tons, with an increase of 14.59%. The constant increase of sugarcane production is a great source to develop bioethanol as a mixture for fuel generated from molasses, and further, the increase enables the government for sugar self-sufficiency.

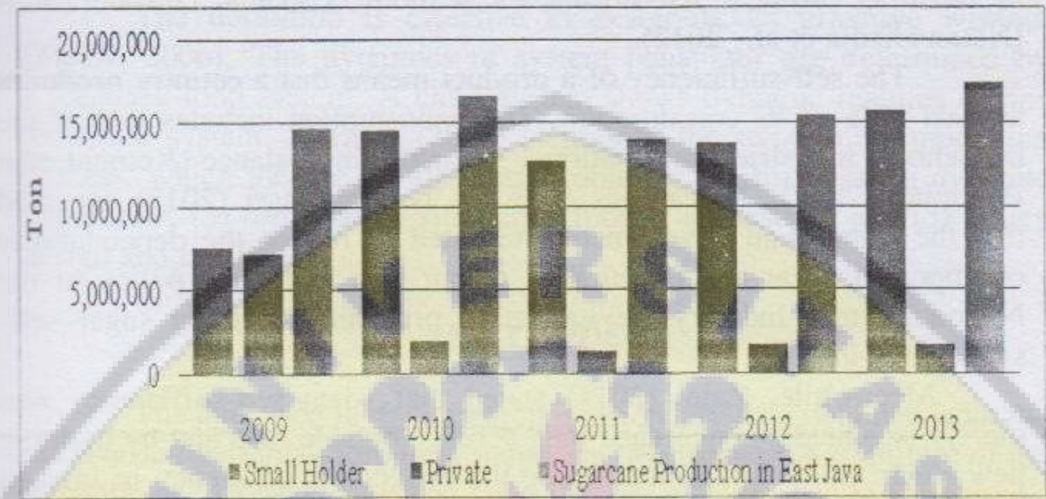

Figure 2. Sugarcane Production in East Java during the Period of 2009–2013
Source: Dewan Gula Indonesia (Indonesian Sugar Board, 2014)

Based on the facts that East Java is the largest sugar-producing area, it has not yet met sugar-production targets as set up by the government to achieve sugar self-sufficiency. Thus, molasses, as a derivative product of sugarcane, which is then processed to bioethanol, apparently has not yet been optimally developed. It is expected that sugarcane would become one of the renewable energy sources that contribute to East Java's gross regional domestic product. Consequently, it would improve the sugar industry, produce more renewable energy, and further improve the regional economy. This research's objectives are analyzing the impact of the revitalization policy in the national sugar industry toward sugar production in East Java and toward the development of molasses.

LITERATURE REVIEW

Sugar self-sufficiency concept. One of the commodities that Indonesian government considers as self-sufficient is sugar. Sugar self-sufficency is manifested when dependency on its export is reduced gradually. The paradigm of sugar self-sufficiency should be carried out by increasing the sugarcane production by additional acreage for the plant (Ginandjar, 2012). However, the strategy of meeting sugar-necessity consumption has not yet integrated with the attempt to achieve food total self-sufficiency. The policy for fulfilling sugar necessity is oriented to fulfilling physical self-sufficiency without economic considerations (Natawidjadja et al., 2012).

The self-sufficiency of a product means that a country produces at least 90% of its consumption. The consumption includes that of the household, industries, and national sugar-trading balance (Kementerian Pertanian, 2012). Researches done by Nugrahapsari (2013) revealed that the Indonesian government attempted to reduce the dependability of imported sugar and encouraged to put into forces the policy of the National Sugar Industry Revitalization program, targeting sugar self-sufficiency in 2014.

Meanwhile, Zaini (2011) stated that when self-sufficiency was merely executed by sugarcane land acreage outside Java and by building new sugar mills without increasing the production efficiency in Java, it would result in shifting the economic rent for sugar. The researches of Cahyani (2008) and Zaini (2011) reveal that when the necessity for sugar consumption has not yet been met, sustainable sugar self-sufficiency will be difficult to achieve.

Dynamic System. A system approach is a rational and intuitive methodology to solve the problems to achieve particular objectives. The approach is best applied for analyzing problems with the following characteristics: (1) complex, in which the interaction among the elements are complex; (2) dynamic, in which the factors are prone to change over time with future assumption; and (3) probabilistic, in which function opportunity is required for concluding both the reference and the recommendation. There are three frameworks as the main guide to analyze the problem using a system approach: (1) cybernetic, being oriented to the objectives; (2) holistic, a whole perspective to the system integrity; and (3) effectiveness, a principle that prioritizes operational and implementable effectiveness over theoretical study to reach an efficient decision (Eriyatno, 1999). A dynamic-system simulation is arranged based on the principles as follows: (1) *cause and effect*, (2) *feedback*, and (3) *delay*. A complete and comprehensive simulation is required to use the principles to generate a system behavior resembling the real circumstances. A causal-loop diagram (CLD) design is also applied in the system thinking to illustrate the cause-effect relation. A feedback relation is capable of yielding varied behaviors in both the real system and in the real-system simulation.

The definition is effective in designing an effective wisdom (Tasrif, 2006). The dynamics of system behaviour are determined by a feedback-loop system. A close system shows dynamic features of one particular system. Sterman (2000) mentioned the steps to the modelling process, which include (1) defining problems, (2) formulating dynamic hypothesis, (3) formulating simulation model, (4) testing, and (5) policy design and evaluation.

METHODS

The data used in this research is secondary data obtained from the Kementrian Pertanian Republik Indonesia (Ministry of Agriculture of the Republic of Indonesia), Dewan Gula Indonesia (Indonesia Sugar Board), Dinas Perkebunan Jawa Timur (East Java Plantation Agency), Badan Pusat Statistik Indonesia (Centre for Indonesian Statistics), Pabrik Gula (Sugar Mills) in East Java and, the publications related to the research in the same areas.

To answer the research's questions, the dynamic-system approach was used. The dynamic system uses data from the period of 2010 to 2025, aiming at observing the long-term model behaviour. The period is selected based on the road map of sugar national sufficiency, and the period is selected based on the road map of national sugar self-sufficiency and the road map of the sugar-industry cluster development (Kementerian Badan Usaha Milik Negara, 2011 dan Kementerian Perindustrian, 2010). The research phases are designed as follows:

1. Need Analysis

Need analysis, as indicated in table 1, is required to analyze the subject's need within the developed system. After the need analysis of every producer related to the model, the next step is developing the need for their identified necessities. Based on interviews and literature, the sugar industry producers include (1) local government, (2) bioethanol factories, and (3) consumers.

Table 1
The Need Analysis of Parties Involved in the Molasses-Development Model and Sugar Production Achievement toward the Regional Economy.

Producers	Necessities
Local government	Increase of sugarcane production and sugar Increase of gross regional domestic product Self-sufficiency achievement
Bioethanol factory	The availability of raw materials Government's policy to support the sustainability of bioethanol production High-priced bioethanol Simple selling procedures The increase on bioethanol use
Consumers	The availability of sugar stocks Cheap and reasonable price Easy to buy

Source: Kementerian Badan Usaha Milik Negara (Ministry of State Enterprises), 2011, bioethanol factory, and consumers

2. Model Structure

The global-structure model indicates the boundary system. The model structure in figure 2 includes interrelated variables in the system. The variable of sugarcane land area affects the production of sugarcane in East Java. The bigger the land area, the higher the sugarcane production will be. Furthermore, in East Java, sugarcane plantation owners are farmers as small holders and private owners. By executing land acreage, it is expected that sugar production and molasses will also increase. Sugar production is determined mainly by rendement as well as installed and utilization capacity. The higher the rendement, the more amount of sugar will be produced. The correlation of molasses and sugar production to regional economy seen in the submodel indicates an increase in the regional economy as resulted from sugar income and molasses processing for bioethanol.

The dynamic-system model determines first the behavior of the downstream sugarcane industry as indicated first by the processing molasses for bioethanol; second, sugar production to reach self-efficiency; and third, their relation to regional economy. A dynamic model is constructed from the development of submodels. When submodels were developed, they became a complete model of the dynamic system.

All variables in the model are interrelated to form a sugarcane-development-model system to identify its contribution to the regional economy, which is then reflected in the sugar income and the amount of bioethanol produced. The mathematical equation showing the relation among the interrelated variables in the submodel is as follows:

Small holders growt prodty = 'Small holders growth productivity'*'Small holders productivity'	(1)
Smallholders production = 'Land area of small holders'*'Small holders productivity'	(2)
Private growt prodcty = 'Private Growth productivity'*'Private productivity'	(3)
Private production = 'Private land area'*'Private productivity'	(4)
Growth of smallholders land area = IF('Land area of small holders'<'Goal smallholders land','% growth of smallholders land area'*'Land area of small holders',((-('Land area of small holders'-'Goal smallholders land')))*1<<1/yr>>)	(5)
Private growt prodcty = 'Private growth productivity'*'Private productivity'	(6)
Growth of private land = IF('private land area'<'Goal private land area','% private'*'private land area'	(7)
'private land area'-'Goal private land area')))*1<<1/yr>>)	(8)
Private production = 'private land area'*'Private productivity'	(9)
Sugarcane production = 'Smallholders production'+'Private production'	(10)
Reduction = '% of reduction'*'Sugarcane production'	(11)
Growth of private land = IF('private land area'<'Goal private land area','% private'*'private land area',((-('private land area'-'Goal private land area')))*1<<1/yr>	(12)
Total land area = 'Land area of small holders'+'private land area'	(13)
Increasing exclusive cpcty = '% exclusive capacity'*'Exclusive capacity ind'	(14)
Days for milling = ('Total Sugarcane Production in East Java'/'inclusive cpcty')	(15)
inclusive cpcty = 'Exclusive capacity ind'*'Init inclusive capacity'	(16)
inclusive capacity = 'Init inclusive capacity'*'Exclusive capacity ind'	(17)
Increasing inclusive cpcty = 'Init inclusive capacity'*'Incresing exclusive cpcty'	(18)
Molasses = 'Inclusive cpcty'*'% Molasses'*'Days for milling'	(19)
Total molasses for bioethanols = (Molasses/4)*1/1000	(20)

Factory capasity = 'Total sugar factory'*'Rate of miling capacity (21)
Reduction = '% of reduction'*'Sugarcane production' (22)
Total sugarcane production in East Java = 'Sugarcane production'-reduction (23)
Total sugar factory = IF('Total sugarcane production in East Java'<=19017877.07*1<<ton>>,31,IF(('Total sugarcane production in East Java'>19017877.07<<ton>>)AND('Total sugarcane production in East Java'<=19633356.97<<ton>>),32,33)) (24)
Yield growth = Yield*'% yield growth' (25)
East Java sugar production = 'inclusive cpcty'*Yield*'Days for milling' (26)
Sugar for farmers = 'East Java sugar production'*0.7 (27)
Total cost = 'Cost cuting and transportation of sugarcane'+('Seed cost'+'Total cost sugarcane'+'Herbicide cost'+'Farmers property tax'+'Fertilizer cost'+'Biaya sewa lhn ttl')*1<<1/ha>> (28)
Total farmers' income = ('Farmers' income from sugar'+'Farmers' income from molasses') (29)
Farmers' total profit = 'Total farmers' income'-'Total Cost' (30)
Sugar revenue for factory = 'Auction price of sugar'*('Sugar for factory')*1<<1/ton>> (31)
Sugar revenue for factory = 'Auction price of sugar'*('Sugar for factory')*1<<1/ton>> (32)
Product domestic regional bruto from molases and sugar = 'Revenue from bioethanols and molasses'+'Sugar revenue for factory' (33)
Total product domestic regional bruto = ('Product domestic regional bruto of East Java'*'% East Java product domestic regional bruto')+'product domestic regional bruto from molases and sugar'*1<<1/yr>>+'Total farmers income'*1<<1/yr>> (34)

3. Policy Simulation

The policy simulation employed in this research is adopted from the policy of revitalizing the national sugarcane industry using the following scenarios: scenario 1, increasing land acreage as much as 3.2% per year; scenario 2, increasing sugarcane productivity as much as 1.6% per year; and scenario 3, increasing rendement for 2.4% per year (Kementerian Badan Usaha Milik Negara, 2011).

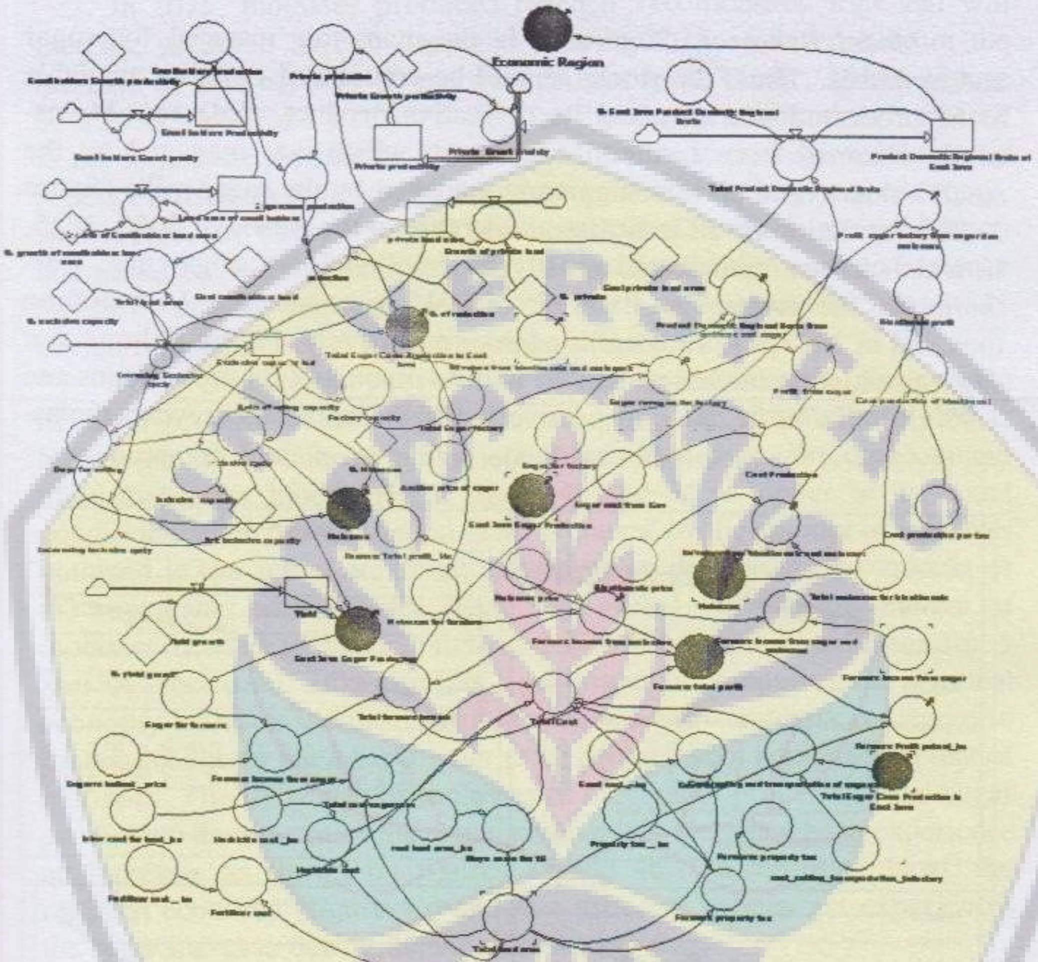

Figure 2. Dynamic Model of Molasses Development and the Sugarcane Production Achievement toward East Java's Regional Economy.

RESULT AND DISCUSSION

Model Behavior. Sugarcane is the main raw material for sugar and molasses. Thus, the stocks should be considered as being available to be processed as sugar and its derivative product, molasses. Molasses is obtained from farmers' sugarcane, which was managed by the small holders, and private sugarcane managed by the sugar mills (figure 3).Thesimulation result indicates an increase in the period of 2010–2025, in which it was contributed mostly by small holders' sugarcane. Furthermore, the increase in the year of 2015 is as much as 16.5 million tons,and in 2025,it is 19.8 million tons, respectively. Figure 3 shows that sugar production increases in 2015 with as much as 1.24 million tons and 1.91 million tons in 2025, respectively. This research also reveals molasses processed for bioethanol as the derivative product of sugarcane.

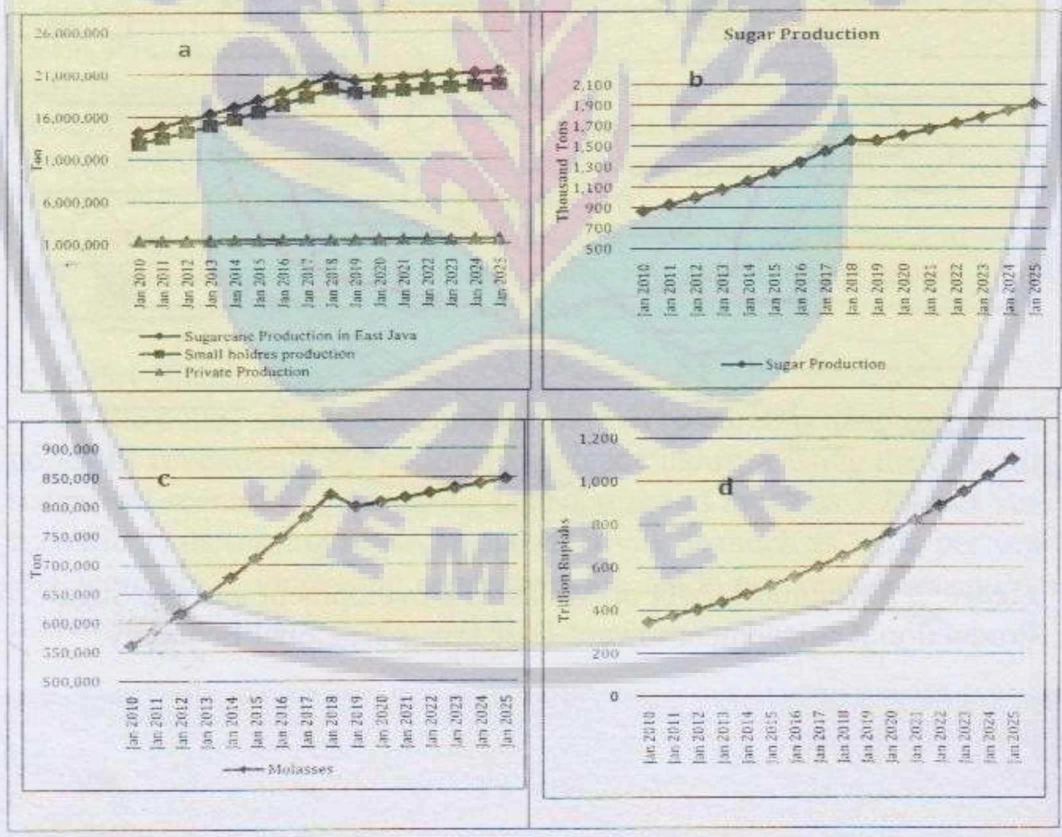

Figure 3. (a) Sugarcane production in East Java; (b) sugar production; (c)molasses; and (d) regional economy in actual condition of the year 2010–2025

In 2015, molasses produced reached 710 thousand tons and will increase as much as 846 thousand tons in 2025 as a result from the increase of land acreage (Dinas Perkebunan Jawa Timur, 2015). Figure 3c also demonstrates that molasses for bioethanol production increased as the sugarcane production did. Meanwhile, the gross regional domestic product is used an indicator in the development of the regional economy. In this case, the development is also contributed by the sugar production and molasses. Simulation results in the actual condition as seen in figure 3d shows that the regional economy in 2015 increasesin 2025 from 511 billion rupiahs to 1.103 billion rupiahs, respectively.

Policy Simulation. The result of simulation indicates that the increase of sugar production and regional economy in the simulation period is higher than that of in the actual condition. Moreover, the development of molasses for bioethanol in figure 4a and 3c is higher in its actual condition than in the simulation. This is caused by the amount of molasses obtained in the actual condition coming from the percentage amount of the sugarcane, which is 4% from cane milled,whereas the number of molasses needed to make bioethanol is 4 kilograms ofmolasses for 1 liter of bioethanol. However,the final output in computing the regional economy indicates thatbioethanol generates higher numbers compared to molasses. This is due tothe higher price ofbioethanol compared to that of molasses. The dynamics of molasses to bioethanol processing and sugar production demonstrates the same patterns in which they both experience an increase, as shown by figures 4a and 4b. On the other hand, the regional economy (figure 4c) shows a different pattern yet experiences the same increase during the simulation period.

Generally, the revitalization policy through scenarios 1, 2, and 3 is able to increase the development of molasses and to increase sugar production toward the regional economy. The highest increase is reflected in the scenario 3, as indicated by the rendement increase (figures 4a, 4b, 4c). Scenario 1 indicates an increase of 0.04%; scenario 2 of 0.016%; and scenario 3 of 0.4%, respectively. Moreover, the development of bioethanol in scenario 1 shows an increase of 0.023%; scenario 2 with 0.028% increase; and scenario 3 with as much as 0.123% respectively. The impact of sugarcane and bioethanol production toward the regional economy is increasing significantly in 5.4% using the scenario 3 simulation. Rendement increase is evidenced to contribute the highest for the regional economy in scenario 3 compared to scenario 1, contributing 0.87%, while scenario 2 only with 0.22%, respectively. In conclusion, sugarcane rendement is required to improve the regional economy.

Figure 4. Comparison of (a)bioethanol, (b) sugar, (c) regional economy in scenarios 1, 2, and 3,period of2010-2025.

CONCLUSION

1. The dynamic-system model is capable of demonstrating the behavior of sugar and bioethanol production development.
2. The policy of revitalizing the national sugar industry managed to increase the sugar and bioethanol production.
3. Policy simulation through scenario 3, which is the rendement increase, simultaneously managed to increase sugar production in East Java to supportself-sufficiency and is able to increase bioethanol production for renewable energy as well as for improving regional economy.

RECOMMENDATIONS

1. It is crucial for the government to increase the sugarcane productivity as material for sugar and bioethanol production by agricultural extensification and intensification.
2. Considering that small holders' sugarcane are owned mostly by the farmers, the government should focus more on the farmers to hinder them from planting more profitable crops.
3. The government is expected to formulate a supporting policy to increase sugarcane rendement.

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