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A Profit Analysis of Indonesia's Cananga Essential Oil Production Using System Dynamics

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ABSTRACT

Cananga essential oil is a type of oil extracted by distillation from freshly-picked cananga flowers. Cananga oil is of a high economic value for its use as fragrances and flavors. In Indonesia, cananga essential oil is majorly produced by small and medium distillers. The most prominent barrier to cananga essential oil production in Indonesia is the fluctuation in its price. This price fluctuation is responsible for the decrease in profits earned by distillers. The aim of this research was to develop a system dynamics model to maximize profits in the cananga essential oil production in Indonesia. A system dynamics approach was employed to figure out the effect of some variables on cananga essential oil production in relation to profits and the interaction of such variables with each other. The scenarios examined in this system dynamics model include to increase the number of distillers, to decrease the fuel expenses, and a combination of both. This research assumed that a change in parameter will be able to increase profits from the cananga essential oil production in Indonesia over the next five years. The results show that increasing the number of distillers and decreasing the fuel expenses have been able to increase cananga essential oil production average by 20% and profits by 62%.

Keywords: *Cananga essential oil; system dynamics; production; profit.*

1 Introduction

Indonesia is one of the world's producers of essential oils, including cananga essential oil (Alighiri et al., 2017). This oil is extracted by distillation from freshly-picked cananga flowers (Pujiarti et al., 2016; Salviana, 2012). Cananga plant (*Cananga odorata* Hook. fil. et Thomson), a member of the family *Annonacea*, is native to China, Myanmar, Thailand, Indonesia, and the Philippines. This plant has been cultivated on a large scale and has been processed into cananga essential oil in Southeast Asia, Madagascar, and Comoro Islands (Kristiawan et al., 2012; Widyastuti et al., 2012). Cananga essential oil can be used in the pharmaceutical industry for drugs production as well as in the cosmetics industry. It can also be used as fragrance and food ingredient. The cosmetics and fragrance industries use cananga essential oil in soaps, shampoos, lotions, and perfumes, while in the food industry, it is used as flavoring. Meanwhile, the pharmaceutical industry uses it as analgesia, anti -infective, and anti-bacteria (Burdock and Carabin, 2008; Mallavarapu et al., 2016; Pujiarti et al., 2016; Utomo et al., 2013; Zhang et al., 2016).

Of late, the cananga essential oil industry has been seeing a rise in terms of p roduct demand, domestic and foreign, yet not many enterprises have the capability of meeting such demand. The cananga essential oil traded in the international and home markets is predominantly still in a semi-finished form as crude essential oil, nearly all of which is produced by small distillers (Gunawan, 2009). The global demand for cananga essential oil is as much as 120–130 tons per year (Julianto, 2016). However, Indonesia is only able to export 25 tons annually (Riyadi et al., 2012).

The key factor in the decline of Indonesia's cananga essential oil production is the fluctuation in its price (Alighiri et al., 2017; Hendrastuti et al., 2012; Rahmayanti et al., 2018). Data shows that the price of cananga essential oil in 1999 reached US $ 85.71 (Widyastuti et al., 2012), in 2012 it decreased to around US $ 30.36 per kg (Salviana, 2012), and currently reaches US $ 50.The fluctuation in the cananga oil price induces fluctuation in small distillers' profits. Such profit fluctuation ultimately leaves many cananga essential oil distillers with a reason to switch to other businesses (Suyono and Purwastuti, 2011). According to Soemarso (2004), profit means the surplus of income over expenses in relation to an enterprise to gain such income over a given period. The greater the production rate, the higher the profits earned (Chang et al., 2017; Lestari et al., 2014; Yan et al., 2018). Aside from price fluctuation, Indonesia's failure to achieve its cananga essential oil production rate target is also caused by some other factors: uncertainty in raw material supply, use of low-quality distillation technology, and low-quality human resources, particularly in terms of motivation and innovation (Alighiri et al., 2017; Salviana, 2012; Widyastuti et al., 2012). The system grows complex with many variables involved. To figure out the effect of such variables in the system, a system dynamics approach can be applied.

This research aimed to develop a system dynamics model for increasing profits in the cananga es sential oil industry in Indonesia. The employment of system dynamics in this research was intended to describe and solve complex problems related to profits from cananga essential oil production in Indonesia. System dynamics is a set of tools with a holistic approach used for simulating and forecasting an object (Jammernegg and Reiner, 2007; Longo and Mirabelli, 2008; Sterman, 2000). It possesses some advantages over other methods, one of which is that its models are able to offer predictions greater in reliability than statistical models. System dynamics provides ways to understand why an industry behaves in a certain way, detects early changes in the structure of the industry, and determines the factors that forecast such behavior in a significant, sensitive fashion (Lyneis, 2000). System dynamics models allow for reasonable scenarios as inputs for a company's decisions and policies (Fritz and Schiefer, 2008; Miller and Newell, 2013; Stephens et al., 2012). The practice and computational tool of system dynamics are used to develop a model for increasing profits from cananga essential oil production in Indonesia. The resulting system dynamics model can be utilized by business actors in the cananga essential oil industry to make short-, medium-, and long-term policies pertaining to the objectives to be achieved.

The remainder of this paper is organized as follows. Section 2 provides a summary of the theory of the cananga essential oil production process and system dynamics. Section 3 contains data collection, data analysis, model development, and also model verification and validation. The results of modeling with system dynamics to define the model of distillers' profits are discussed in section 4. Finally the conclusions are given in s ection 5.

2 Literature Review

2.1 Cananga Essential Oil Production Process

Cananga essential oil is extracted by isolating cananga flowers through distillation, a process of separating a fast - evaporating component from another component of a relatively slower evaporation rate or a separation process of an easily evaporating mixture (Salviana, 2012). Cananga essential oil distillation can be performed in a number of ways: water distillation, steam and water distillation, and steam distillation (Skaria, 2007).

The distillation process many of the players in the Indonesian cananga essential oil distilling industry favor is water distillation (Alighiri et al., 2017; Salviana, 2012). Its advantage lies in its ease to perform and the little amount of capital required. Despite the advantage, however, this distillation method produces cananga essential oil of low qualities and low grades, sometimes with the presence of an acid hydrolysis process and mixed with byproducts (Alighiri et al., 2017; Salviana, 2012). This distillation method takes a fairly long time of around 62 hours for a single production process (Salviana, 2012) and has a rendement of 0.41% (Muchjajib and Muchjajib, 2010), but the human resources needed are not too many (only 4–5 people per production process) (Widyastuti et al., 2012). On average, distillers in Indonesia have 3–5 boilers of a maximum capacity of 400 kg of cananga flowers and produce 1.2 kg of cananga essential oil per 50 kg of raw material (Widyastuti et al., 2012). This distilling method is of various production capacities and produces essential oil of various qualities (Salviana, 2012).

2.2 System Dynamics Approach

System dynamics is a method of learning to which extent a system is defendable from the interferences external to it. It is related to a system's behavior which changes over the time. One uses it to understand and explain the information feedback regarding such a behavior, and to design the information feedback structure as well as an appropriate control policy through system simulation and optimization by quantitative and qualitative models (Coyle, 1996). Meanwhile, a definition by (Sterman, 2000) says that system dynamics is a method of acquiring information on dynamic complexity and on sources of policy resistance. System dynamics models are unique in their ability to unveil important and oftentimes counterintuitive insights relating to behaviors and are able to offer useful contributions to policymakers (Ghaffarzadegan et al., 2010). The difference between system dynamics and other approaches lies with the use of feedback loops, stocks, and flows to help illustrate how one system is connected by the feedback loops of real-world behaviors over the time which are non-linear and laden with uncertainties (Sterman, 2000). The aim of the system dynamics methodology based on the philosophy of causation is to gain an in-depth understanding on the workings of a system (Asyiawati, 2002).
Drawing a comparison between results can be performed in two ways:

1. Verification, to examine the errors in the model and ensure that the model functions according to the logic of the system object (Sterman, 2000), and
2. Validation, to check whether the simulation's conceptual model is an accurate representation of the real system being modeled (Muhammadi et al., 2001).

3 Methodology

3.1 Data Collection

This research was conducted in Blitar Regency, East Java, Indonesia. The regency was selected as the research site as it is among the largest cananga essential oil producers in Indonesia (Salviana, 2012; Widyastuti et al., 2012). In order to achieve the research's objective, data, information, and knowledge were collected from primary and secondary sources through observation, discussion, and interviews with the respondents. The respondents enrolled had to meet the criteria of representativeness and credibility in the information provision. In this research, the respondents were cananga essential oil distillers in Blitar Regency. Interviews were conducted to obtain qualitative and quantitative data related to the cananga essential oil distilling enterprise studied. The data gathered were then processed by the system dynamics methodology.

The simulation of the model's behavior involved historic cananga essential oil production data over the last ten years (2008–2018) and a forecast for the next five years. In this research's system dynamics simulation, the Vensim 5.2 software was employed to build a profitability model of essential oil production.

3.2 Data Analysis

The system dynamics model explained in this research considered the profit from the production of cananga essential oil in Indonesia which was dynamic in nature (i.e., changing from time to time). This model was developed within two system dynamics phases: a qualitative and a quantitative phase (Ferreira et al., 2016). The former phase was composed of the conceptual problem preparation. This included the analysis of the variables affecting the profit from the cananga essential oil production in Indonesia, the collection of information about these variables and the specification of the objective of the study presented in the form of a causal loop diagram. The latter phase, the quantitative phase, referred to technical problems, including the mathematical formulation, verification, validation, and specification of scenarios.

The stages of problem-solving in a system dynamics approach, include, according to Muhammadi et al. (2001), (1) understanding the system to be analyzed in relation to the situation and condition of the problem, (2) setting up the conceptual system, which involves the identification of the system actors and the relationships between the actors as a basis for the development of the causal loop diagram, (3) limiting the scope of the analysis for reducing the system's complexity, (4) translating the relationships between elements or between actors into the model's programming language, (5) verifying and validating the model's behavior in comparison with the real- world system's behavior through a behavior validity test (Barlas, 1996), and (6) developing policy scenarios.

3.3 Model Development

The development of the profitability model of the cananga essential oil production in Indonesia was conducted by identifying and evaluating the variables involved in the system. Variables that influenced the profitability of cananga essential oil distillation include the total cost incurred by the distiller, the cananga essential oil production amount, the amount of cananga flower supply to the distiller, the amount of cananga essential oil sales, and cananga essential oil price. The relationships and feedbacks of the variables related to the distilling profit are illustrated in a causal loop diagram (CLD) (Figure 1), which is a system dynamics tool that encourages the model maker to establish a real-world system concept in the form of a feedback loop (McLucas, 2003). In a CLD, arrows denote the directions of the influences, and the marks (plus or minus) the types of the influences. A plus mark (+) suggests that two variables change in the same direction, while a negative mark (-) means that two variables change in opposite directions (Sterman, 2000).

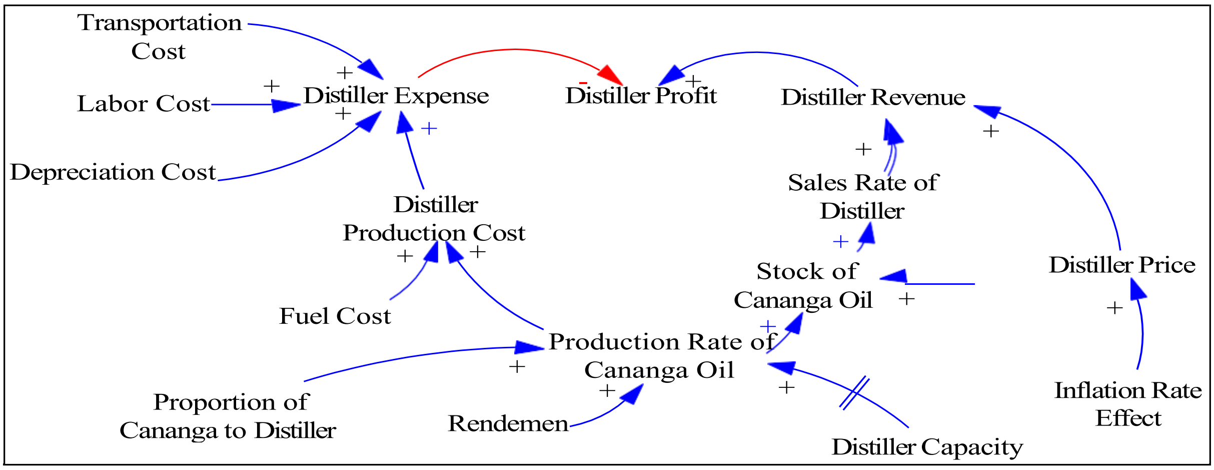

Figure 1. A causal loop diagram of distiller's profit

The complex interactions and causal relationships between the variables of cananga essential oil distiller's profit made it necessary to expand the effort to understand the phenomenon from CLD to a a stock and flow diagram. A stock and flow diagram is used to analyze the variables' behavioral changes, along with a series of simulations related to cananga essential oil distiller's profit (Sterman, 2000) (Figure 2).

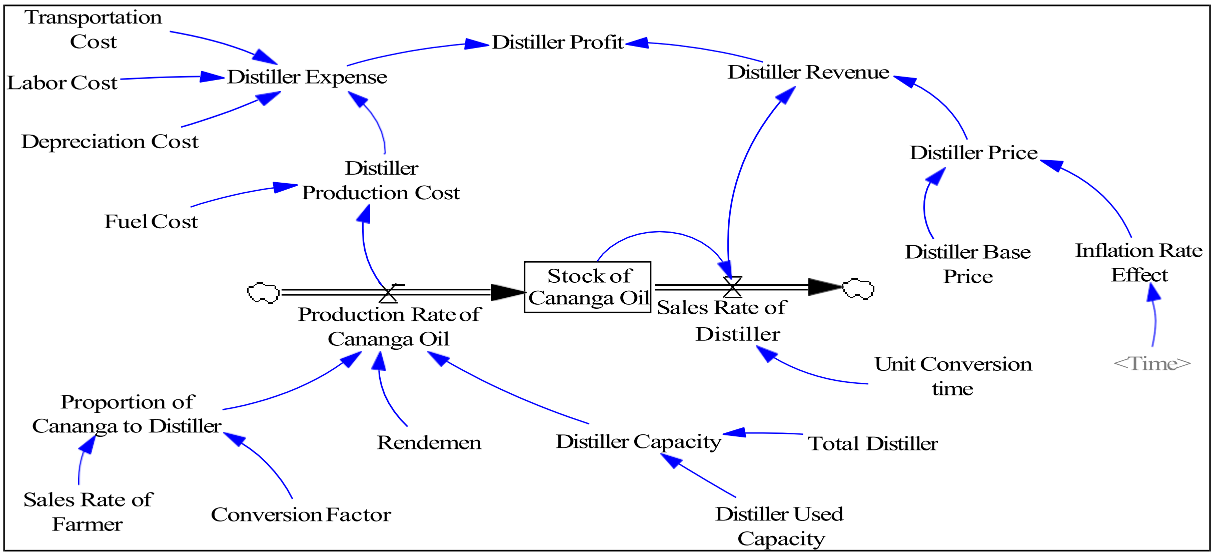

Figure 2. A stock and flow diagram of distiller's profit

3.4 Model Verification and Validation

Model verification was conducted to test the model's consistency. It was conducted by examining the formulations and units of the variables in the model. If no error was present in the model, then the model was verified. In this research, verification was performed by running a debug on the Vensum 5.2 software which showed that the model's logic was functional. Upon the verification in the model structure stage, the same was conducted through the unit test in the model which showed that the units used were acceptable.

Model validation was performed to ensure that the model met the purpose of the model development and that it could represent the existing system (Sterman, 2000). Barlas's model was used to test the model validity. This model was deemed valid when the percent error from mean (E_1) was less than 5% and the percent error from variant (E_2) was less than 30% (Barlas, 1996). Testing was carried out based on the following equation.

$$E = {|S - A|}/{A}$$

Where

A : Actual data
S : Simulation output

The validity of the model was tested by calculating the E_1 and E_2 values for the variables cananga oil production rate and distillers' profits (table 2).

Table 1.

Results of Validation of Quantitative Test

Variable	Value	Condition	Result
Production Rate	E_1 = 1.18%	$E_1 \leq 5\%$	Valid
	E_2 = 22.29%	$E_2 \leq 30\%$	Valid
Profits	E_1 = 2%	$E_1 \leq 5\%$	Valid
	E_2 = 27%	$E_2 \leq 30\%$	Valid

4 Results

4.1 Simulation Result

The entire model is simulated using Vensim 5.2 software environment. The system dynamics simulation was run for 60 months (5 years), and the simulation results were recorded monthly for cananga essential oil production rate and distillers' profits.

A Cananga Oil Production Rate

The simulation results for the variable cananga oil production rate between period 1 and period 60 are outlined in Figure 3.

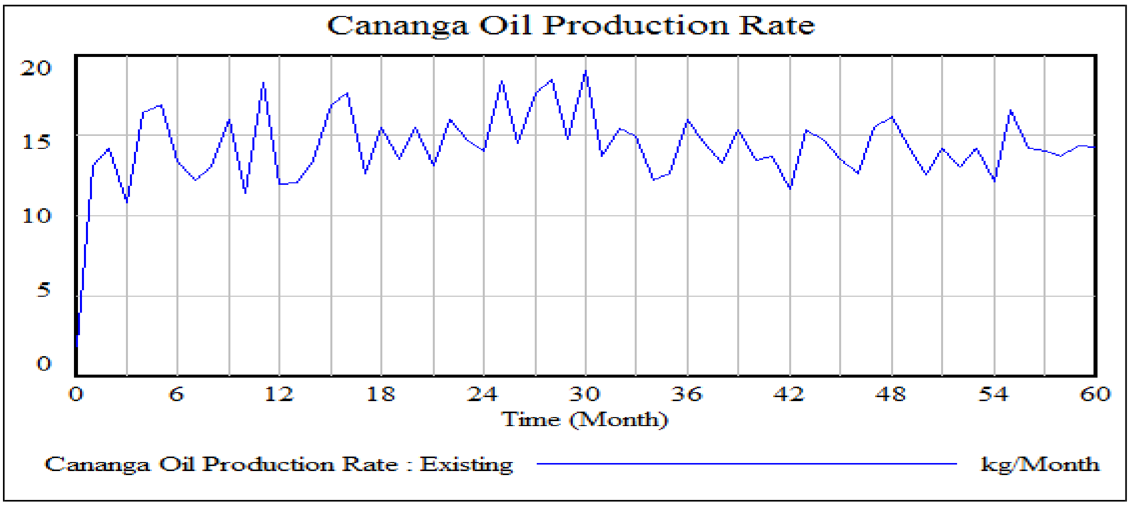

Figure 3. Simulation Results for the Variable Cananga Oil Production Rate

According to the calculation, the average cananga oil production rate under current conditions was 14.47 kg/month. The main factor that causes the fluctuation of the cananga essential oil product ion is the unceain supply of cananga flowers. This condition is in accordance with research conducted by Widyastuti et al. (2012) which states that the production of cananga essential oil is strongly influenced by the supply of cananga flowers to the distiller. To find out about the variables affecting the cananga oil production rate an analysis using a causes tree diagram was carried out (Figure 4).

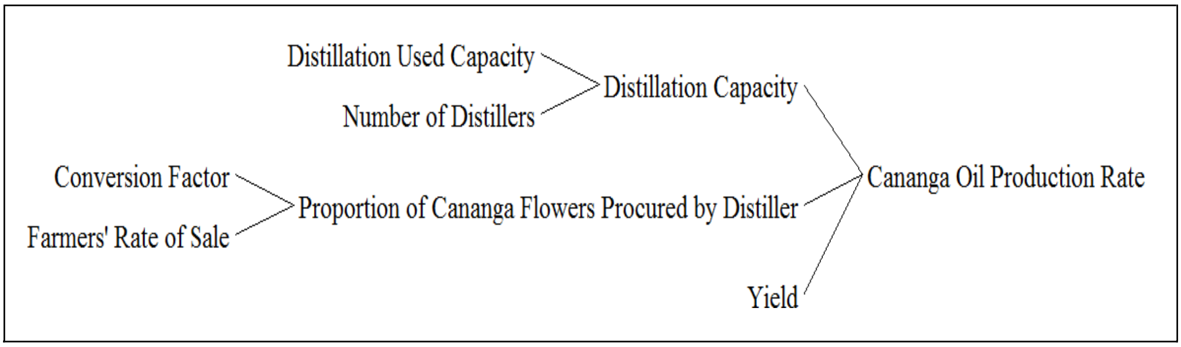

Figure 4. Causes Tree Diagram of Variables Affecting the Cananga Oil Production Rate

B Distillers' Profits

The simulation results for the variable distillers' profit for period 1 to period 60 are outlined in Figure 5.

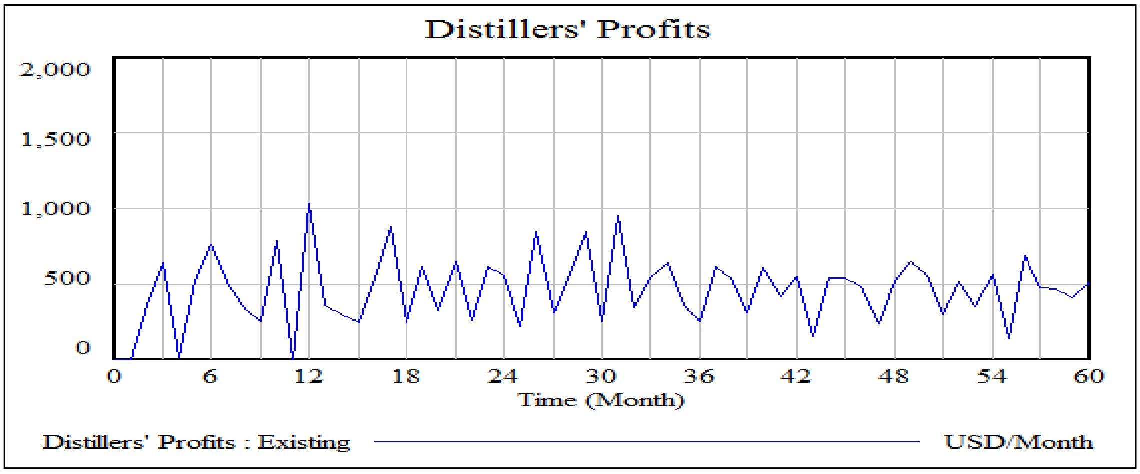

Figure 5. Simulation Results in the Variable Distillers' Profits

According to the calculation, distillers' average profit stood at US$474.44/month. The simulation results show that the fluctuating profits of the distillers are due to the fluctuating price of cananga essential oil, the cananga essential oil production amount, and the total costs incurred by the distillers. This is in accordance with research conducted by Fibrasia et al. (2012) and Murni et al. (2016). To find out about the variables affecting distillers' profits an analysis using a causes tree diagram was carried out (Figure 6).

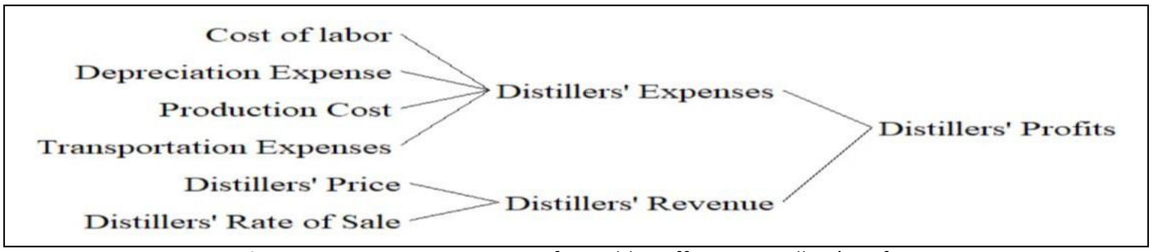

Figure 6. Causes Tree Diagram of Variables Affecting Distillers' Profits

4.2 Policy Scenarios

System dynamics simulation was used to analyze and evaluate the profits from cananga essential oil production in Indonesia that changed over time. The aim of the scenarios was to increase the distillers' profits and the cananga essential oil production. The study identified three policy scenarios for evaluating the change of the profits from cananga essential oil production due to changes in market structures.

Scenario 1: Increase the number of distillers

A significant gap existed between the number of farmers and the number of distillers. According to the data from the Statistics Indonesia in the Regency of Blitar in 2018, there were 1,003 farmers but only 8 small distillers capable of essential oil production. The number of distillers had decreased from 33 within the last two decades. This decrease in the number of distillers was attributed to profit uncertainty (Widyastuti et al., 2012). To overcome this problem it was recommended that the number of distillers should be increased. To this end, it was deemed necessary for the government to provide trainings as an incentive for distillers.

In this policy scenario the number of distillers was changed from 8 in the actual condition to 10. Simulation results indicate that cananga oil production rate could be improved by 20% and the profits mean by 30%.

Scenario 2: Decrease the fuel expenses

Based on interviews with some small distillers, the expenses incurred for fuel accounted for about US$57 /kg. The fuel used for the cananga essential oil production was corn waste. A couple of researchers have proved that distillation waste can be used as an alternative fuel. Adiwijaya and Malika (2016) conducted a study of the use of patchouli oil distillation waste as a briquette material. Similarly, Sugiarto and Sulistyo (2010) reused patchouli oil distillation waste as an alternative fuel for the patchouli oil distillation.

In scenario 2 fuel expenses were reduced by 50%. The simulation results did not yield any increase in the production rate but only in average profits (45%).

Scenario 3: Increase in the number of distillers and decrease in fuel expenses, simultaneously

Scenario 3 is a combination of scenario 1 and scenario 2. The variable number of distillers was changed by 25% of the actual condition, and the variable fuel expenses was changed from US$53.57/kg in the actual condi tion to US$35.71/kg. The results show that scenario 3 was able to increase the cananga oil production rate by 20% and increase the average profits by 62%.

The simulation results for the variables cananga oil production rate and distillers' profits for scen arios 1–3 within a five-year period are shown in Figures 7 and 8.

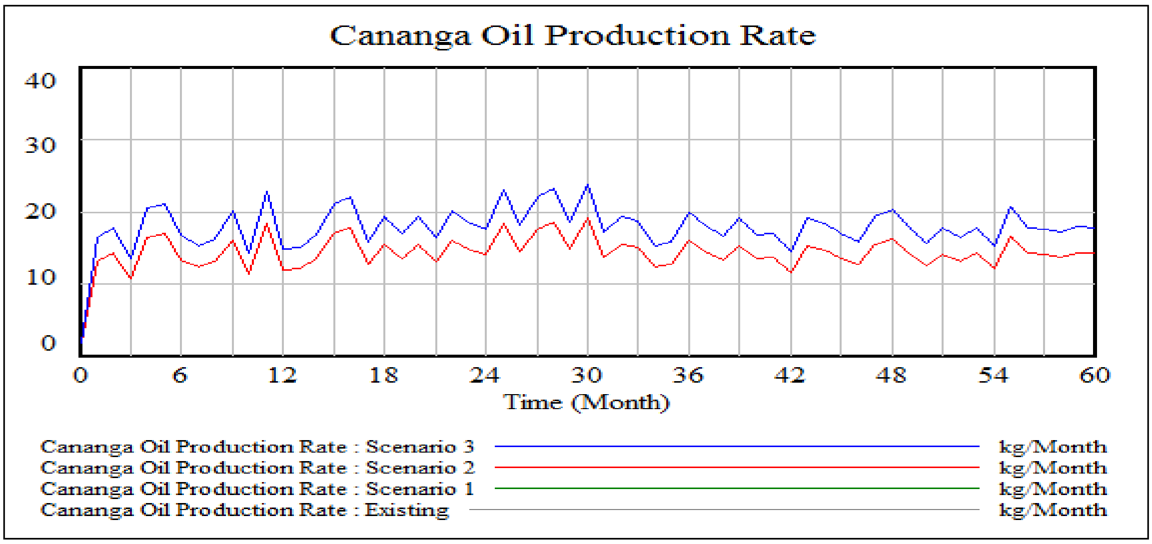

Figure 7. Results of Simulation of the Policy Scenarios for the Variable Cananga Oil Production Rate

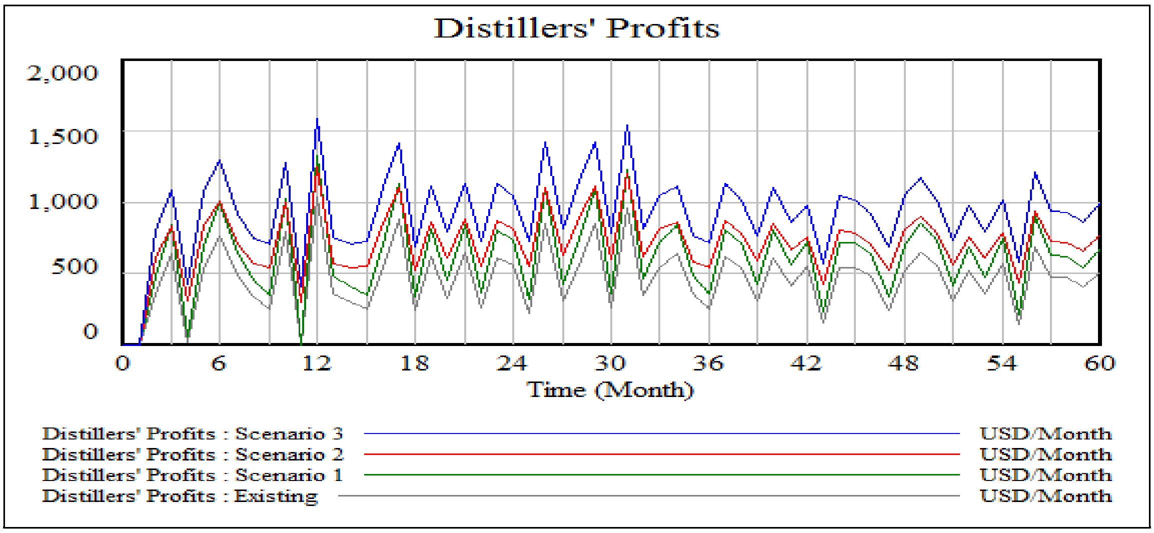

Figure 8. Results of Simulation of the Policy Scenarios for the Variable Distiller s' Profits

5 Conclusions

In this research, a system dynamics model was developed based on the causality between variables that affected cananga essential oil distiller's profit, including cananga flower supply to the distiller, rendement, distiller's production capacity, total cost incurred by the distiller, and cananga essential oil price. The research results showed that there were 16 variables affecting the profit from cananga essential oil production, as illustrated in a causal loop diagram. The model was simulated based on the Vensim 5.2 software. The simulation was performed for 60 months (5 years) to figure out the effects of the variables identified on the distiller's profit. This model was tested in three different policy scenarios. The best policy scenario for increasing the profit from the cananga essential oil production in Indonesia was the third scenario which assumed an increase the number of distillers and a cut down of fuel cost. The result from the simulation using this scenario demonstrated average increases in production and in profit by 20% and by 62%, respectively.

The model can be considered a suitable complementary tool for decision-making in efforts for improving the profit from cananga essential oil production.

This research also suggested that the cananga essential oil agroindustry has the potential to develop. A good integration between actors in the industry, the government, and researchers may enhance the competitiveness of the cananga essential oil agroindustry and sustain the system in the long run.

Limitations of this research are due to the short model period of five years and the limitation on boosting the profit from canaga essential oil distillation. Further research may design a detailed cananga essential oil agroindustry concept and analyze its feasibility. It is also recommended to study further alternative scenarios for identifying the most effective and powerful configuration in the canaga essential oil agroindustry.

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