Applying System Dynamic to Predict Production and Market Demand of Patchouli Oil

by Dina Rahmayanti

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Abstract: Using a system dynamic model, this study attempts to identify the supply chain and analyze the gap between patchouli oil output and demand for the next several years. From 2018 through 2025, the simulation will run. The simulation revealed that collectors are unable to meet the amount of patchouli oil required every year. Patchouli oil production in West Pasaman was unable to meet overseas demand in 2018 and 2019, but the expected order for 2020 to 2022 was well met. The request was not fully satisfied the following year. The quantity of planting areas has a beneficial impact on wet patchouli, which in turn has a positive impact on patchouli oil production. Patchouli oil output can be increased in West Pasaman by establishing a patchouli planting area. In addition to developing policies, the government must communicate the value of quality to local communities. So that the demand for patchouli oil in West Pasaman grows, farmers require training and quality training.

Keywords: patchouli oil production, patchouli oil demand, system dynamic

1 Introduction

Pogostemoncablin (Lamiaceae) or patchouli is an original plant from Indonesia, Malaysia, and the Philippines. This plant is a kind of dense herb which is a member of the mint family. "Nilam" or "Dilem" is the most popular name for this plant in Indonesia. Patchouli is one type of plant that produces essential oils and has become the community of Indonesian exports in recent years. 60% of essential oil exported by Indonesia is patchouli oil, and 90% of world patchouli oil originated from Indonesia. Patchouli oil obtains from the distillation of stems and patchouli leaves. Patchouli oil as a type of essential oil widely is used in the production of cosmetics, perfumes, antiseptics, medicines, "flavoring agents" for food, beverages, cigarettes, and aromatherapy(Elguea-Culebras, 2016; Barros et al., 2016; Złotek et al., 2016; Adrar et al., 2016). Patchouli oil has a substantial fixative property, which serves to create a longer fragrance on the perfume, so its use as a raw material form. Stable smelling oil extracted from leaves widely used in perfumes, incense, detergents, and hair conditioners (Swamy and Sinniah, 2016; Paul, 2010). In many famous fragrances is found a high composition of patchouli oil.

West Sumatra is one of Indonesia's leading hubs for essential oil research and development as evidenced by Presidential Regulation No. 28 of 2008. Patchouli oil is the essential oil with the highest percentage of exports when compared to other essential oils. Around 90% of the world's demands are met by Indonesia, which produces 1600 tons each year (Ministry of Industry, 2015). Patchouli oil is produced in Indonesia's numerous locations, including West Sumatera's West Pasaman. Patchouli oil production in West Sumatra has been declining for the last five years, according to data from the Indonesian statistics department, resulting in low productivity. Patchouli oil production has been declining in recent years due to low prices, uncertain prices, and high production costs at the farmer level. During the refining process, fuel prices and personnel expenses have an impact on production costs. Some farmers choose to leave patchouli plants to grow rather than harvest and distill it in this situation. If the patchouli oil sector grows to its full potential, it will benefit the entire community.

Regarding raw materials, the existence of industry can increase the added value of patchouli plants that have not utilized optimally. If viewed from the current resources in West Pasaman, the amount of patchouli oil production should increase and more than current production. There many reasons: a. From the side of the area, west Pasaman has a large plantation area, b. from the bottom of the plant, patchouli is natural to breed, and c. from the side of processing technology, patchouli oil distillation able to use simple and accessible tools. However, the current problems of patchouli oil productivity continue to decline. Therefore, it is necessary to research the amount of patchouli oil production in West Pasaman in the next few years, and the prediction of demand for patchouli oil in the next few years based on resources available.

This study aims to identify the supply chain, the gap analysis between the amount of patchouli oil production and demand for the next few years in West Pasaman. Then, if there is a disparity between patchouli oil output and demand, figure out how to solve the problem. Prediction of patchouli oil output and demand as a basis for designing a strategy for the future development of the patchouli oil agroindustry. A system dynamics model will be used to forecast the amount of patchouli oil production and demand for the next few years. When compared to traditional forecasting methods, the system dynamic simulation model has significant advantages. Models based on System Dynamics can provide more accurate estimations than statistical models. Dynamic system models provide a technique to comprehend industrial behavior, identify it against early changes in industrial structure, and decide which aspects are significant and sensitive in predicting behavior.

System dynamics allow to determinate plausible scenarios as input for decisions and policies company. In this study, the productivity of patchouli oil influence by various factors that tend to change. Estimating patchouli oil productivity for the next period is needed as an analysis material to design a development strategy of patchouli oil agroindustry. The results can be expected to show whether the number of patchouli production in West Pasaman can meet the demand of patchouli oil or not able to fulfill the requirement of patchouli oil. It is necessary to determine factors so that the order of patchouli oil is often not fulfilled. System dynamics is a professional field that deals with the complexity of the system. System dynamics interprets real systems into computer simulation models that allow seeing how the structure and policy of decision making in the order (Forrester, 2010).

2. Material and Method

2.1 Material

A complex system dynamic approach, according to Sterman (2000), necessitated formal models and simulation methodologies for testing, improving, and designing new policies. System dynamic simulation, according to Suryani (2006) in his book "Modeling and Simulation," is a continuous simulation invented by Jay Forrester (MIT) in the 1960s that focuses on the structure and behavior of systems with variables and feedback loops. The caustic diagram depicts the relationships and interactions between variables.

Because agroindustry systems are complex and vary over time, dynamic systems were used in this study. A reliable dynamic diagram system to address this problem, based on past reviews. There is a tendency to modify the situation in the patchouli oil agroindustry; for example, there is an uncertain price shift that impacts the amount of patchouli oil produced. There are additional associated elements that are causing the amount of production to be reduced, in addition to price. The system is complicated due to the large number of variables that interact with one another.

2.2 Method

The Supply chain model for patchouli oil was designed to know the current and future conditions. Models created using system dynamics. System dynamics are used because of the complexity of existing systems where many factors influence the development of patchouli oil agroindustry in West Pasaman.In the case of agroindustry patchouli oil, there is a tendency for the situation often changing; for example, there is an uncertain price change that affects the amount of patchouli oil production. Price is not the only cause of the decline in production, and there are still other factors that are related. The number of variables that influence other variables makes the system complex. The use of dynamic systems allows us to see the mechanism of feedback and change each other between existing factors, able to predict conditions in the future.

The first step in this research was begun by designing the supply chain of patchouli oil in West Pasaman from farmers to exporters. The supply chain was developed based on surveys and interviews with actors. Agroindustry actors consist of farmers, intermediate trades, collectors, and exporters.

The second step was determining variables and constants that affect total patchouli oil production and demand.

The third step was designing a causal loop diagram for patchouli oil production in West Pasaman.

The fourth step will be to make the relationship between component then designed system dynamics program using Powersim software.

The fifth step was to verify and validate simulation results by comparing the results obtained from the simulation model with existing conditions. From the results obtained were expected able to illustrate the problems going on, whether the amount of production has not been able to meet the demand, or in contrast, the amount of output can meet demand well.

Data consists of primary and secondary data, primary data obtained through interviews and surveys with farmers, intermediary traders, and collectors, while primary data is collected from the Indonesian Statistics Center. The number of actors interviewed in this study was 5 farmers, three intermediary traders, three collectors, each provided in West Pasaman District, and two exporters located in the city of Padang. Primary data consists of the patchouli oil production process and actors involved in the patchouli oil supply chain. Secondary data include the number of planting areas in recent years (2011-2018), the percentage of patchouli leaves and stems declining to become dry patchouli, the percentage of yields, the number of exports of essential oils in recent years and the amount of patchouli oil production in past years (2011-2018). Data on the total planting area, the amount of patchouli oil production, and the amount of patchouli oil data on the amount of patchouli oil production are taken from the book profile of West Pasaman Regency and Indonesian Plantation Statistics 2015-2017. While data on the reduction of the percentage of patchouli leaves and stems become dry patchouli, the rate of yield is taken from the patchouli cultivation manual and the production of essential oils.

3. Result and Discussion

3.1 Result

a. Patchouli Oil Supply Chain

Patchouli oil supply chain was designed based on interviews and surveys with farmers, traders, collectors, and exporters in West Pasaman and Padang. Patchouli oil obtained from the extraction of patchouli dried leaves and stems. The extraction process is called distillation. Distillation is done by small and medium enterprises (SMEs) in West Pasaman. Either patchouli farmers will sell dry patchouli directly to distillers or perform distillation by themselves. Distillers and farmers supply patchouli oil to traders or collectors who sell it to exporters. Patchouli oil goes through many steps before being used by manufacturers. Figure 1 shows the patchouli supply chain in West Pasaman.

b. Causal Loop Diagram

Enhancement on the planted area will have a positive effect on increasing wet patchouli production every time, of course, will also have a positive impact on productivity. One effort to increase the productivity of agricultural products is a growing area of planting. Wet patchouli produced will be dried in 2-3 days; after patchouli dry, the distillation process done. The percentage of rendement strongly influenced by the type of patchouli and the proportion between stem, patchouli leaf. Patchouli stems produce less yield than patchouli leaves, so for high rendement required more leaves proportions. The relationship between factors can be seen in Figure 2.

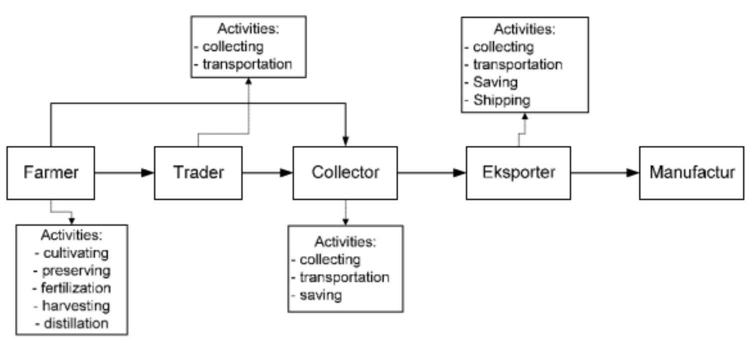

Figure 1. Patchouli Oil Supply Chain

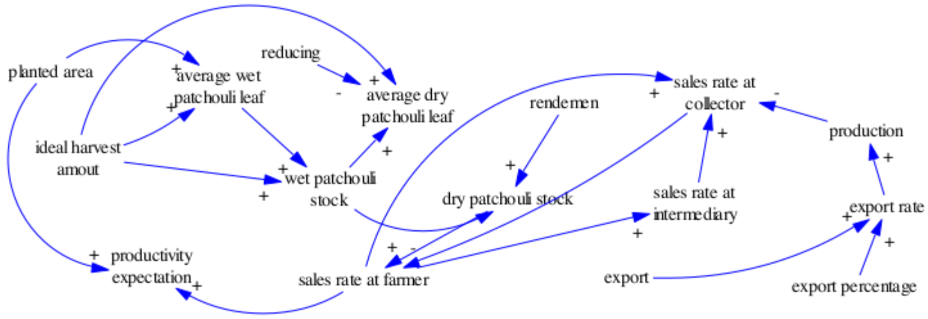

Figure 2. Causal Loop System Dynamic for Forecasting Production and Demand of Patchouli Oil in West Pasaman

c. Stock Flow Diagram

The number of patchouli production will calculate in ideal conditions based on studies that have done—total production based on the number of planted areas. Theoretically, one hectare of land can produce 5-7 tonnes of patchouli per year. Wet patchouli that has been harvested will be dried, the percentage of dry patchouli produced from wet patchouli is 30 percent. The next stage is cutting dried patchouli leaves and stems into smaller parts, making it easy to do the distillation process. Yield from the distillation process varies depending on the type of patchouli planted. Patchouli oil that is ready to be produced will be purchased directly by intermediate traders or collecting traders. An intermediate trader at a later stage will sell it to the collector. The only collector can sell to exporters, and exporters usually do not want to receive direct patchouli oil from farmers or intermediate traders because they sell in small parties. Furthermore, exporters will buy patchouli oil for various manufacturing companies abroad.

Market demand will be calculated based on the value of patchouli export in recent years. Export data available in the Indonesian statistics center is only the export of essential oil. Data will convert from essential oil export value to patchouli oil export value. Where 50% -60% essential oil export value is patchouli oil. Then this export value will be used as a reference for the demand of patchouli in West Pasaman. The stock-flow system dynamic for forecasting production and demand of patchouli oil in West Pasaman can be seen in Figure 3.

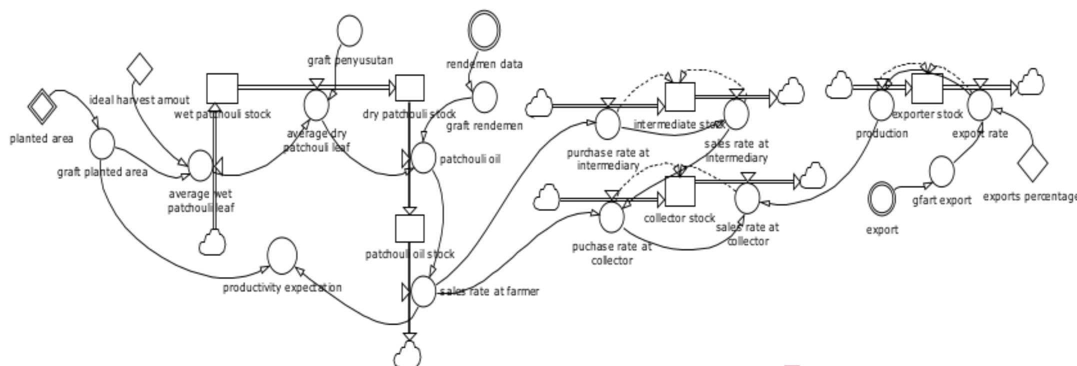

Figure 3. Stock Flow System Dynamic for Forecasting Production and Demand of Patchouli Oil in West Pasaman

Dry patchouli reduces up to 70% from wet patchouli; the amount of patchouli oil produced varies depending on the type of patchouli. Patchouli oil at farmer's level is sold to collectors or through intermediate traders, and intermediate traders will sell patchouli oil to collecting traders. From interviews conducted to some actors, farmers sell patchouli oil to intermediate traders because the location of collectors is quite far. In contrast, farmers who are around collectors sell patchouli oil directly to collectors. It estimated that almost a third of farmers sell to intermediate traders. Relationships between variables, constants, and levels can be expressed as follows:

$$desired\ planted\ area_t = enlargement\ area_t + graft\ current\ area_t$$

$$graft\ current\ area_t = GRAPHCURVE(TIME; STARTTIME; 1 << yr >>; 'current\ area') * 1 << ha >>$$

$$enlargement\ area_t = \frac{rate\ production_t}{enlargement\ area_t}$$

$$rate\ production_t = po\ production_t\ x\ acceleration$$

$$exporter\ po\ inventory\ (t) = \int_{to}^{t} [total\ po\ demand\ exp(s) - shipment(s)]ds + exporter\ po\ inventory(t0)$$

$$desired\ inventory_t = shipment_t\ xdesire\ inventory\ coverage$$

$$inventory\ adjustment_t = \frac{(exporter\ po\ inventory_t - desired\ inventory_t)}{inventory\ adjst}$$

$$order_t = inventory\ adjustment_t + average\ shipment_t$$

$$order_t = DELAYMTR(order; 'time\ to\ place\ order'; 3; order)$$

3.2 Discussion

This study is simulating using system dynamics to see the gap between the amount of patchouli oil production in West Pasaman and the level of patchouli oil demand carried out for the next seven years from 2018 to 2025. Figure 4 shows a comparison of average patchouli oil sales in each actor. From the simulation result, average sales of three actors tend to fluctuate for the next few years. The highest average farmers sales will be expected to occur in 2018, which is 266 tons/yr, while the lowest average sales will arise in 2021, which is 189.16 tons/yr. Farmers will sell patchouli oil to intermediate traders and collectors. It is estimated that almost 70% of sales made to collectors, and the rest is to intermediate traders. In the next stage, an intermediate trader will sell it to the collector. There is a difference in purchase price between traders and collectors. Usually, the purchase price of intermediate traders is lower IDR 20,000 than the collector. Average sales at the collector level predicted able to increasing and decreasing for the next few years, and the highest sales increase will occur in 2019. At 2020 it will decline quite drastic, 91 tons/yr, and then tend to the slight increase in 2021.
Furthermore, the number of average sales at the collector level continues to increase until 2025. It is undoubtedly in line with the level of sales at farmers. Slightly different from the average sales at farmers and collectors level, the number of patchouli oil sell in intermediate traders tend to be stable.

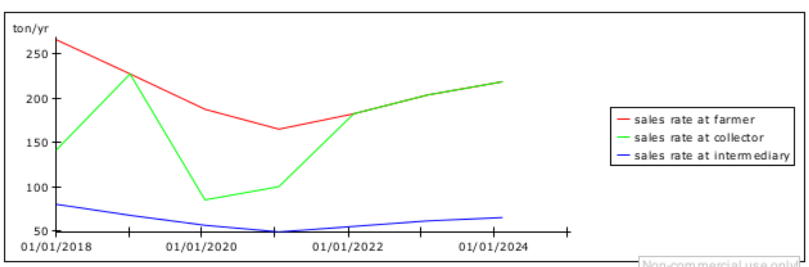

Figure 4. Comparison of average patchouli oil sales in each actor

Figure 5 shows the number of patchouli oil from foreign demand from 2018 to 2025. The amount of patchouli oil demand tends to fluctuate until 2021, while the following year tends to increase. The lowest number of orders predicted will occur in 2020, then a slight increase in 2021. While the highest demand reported will arise in 2024 and 2025.

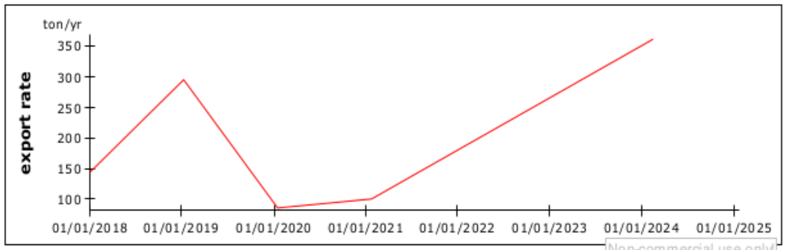

Figure 5. Patchouli Oil Demand for West Pasaman

Figure 6 shows a comparison between the number of patchouli oil production in West Pasaman represented by average selling of patchouli oil at the collector level and the number of demand for patchouli oil represented by export data. From figure shows that the number of production and demand for patchouli oil tends to fluctuate from 2018 until 2025. Simulation results show that the amount of patchouli oil demands not every year able to be fulfilled by collectors. In 2018 and 2019, overseas demand has not been able to be achieved by patchouli oil production in West Pasaman, while 2020 to 2022 predicted order fulfilled well. Furthermore, the following year the request has not been appropriately fulfilled.

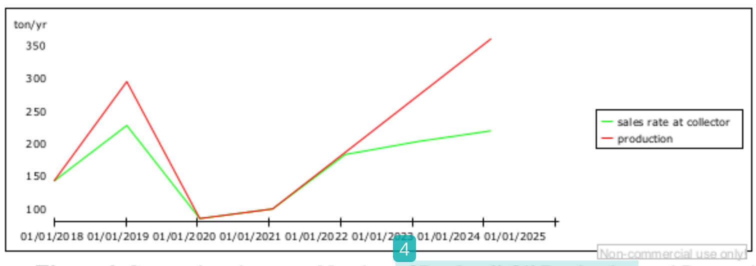

Figure 6. Comparison between Number of Patchouli Oil Production and Demand in West Pasaman

System dynamics model for forecasting the number of patchouli demand in this study was made based on the number of planted areas in recent years. Whereas for other factors, it is considered not to affect production, because it is assumed to be ideal. The number of planting areas has a positive influence on wet patchouli, which positively affects the production of patchouli oil. Patchouli oil production in West Pasaman can be increased by adding a patchouli planted area. The land is one of the factors that can increase production value (Falo, 2016, Thamrin, 2014). It expected that this research could become a foundation for the government in designing strategies to increase the amount of patchouli oil production in West Pasaman so that it can meet the foreign demand.

Patchouli oil sales currently in West Pasaman still meet foreign demand, while the domestic market does not yet exist. It could be an opportunity for the establishment of patchouli oil industry derivatives in West Sumatra. One of the requirements for the establishment of a factory is close to raw materials. Human resources are very fulfilling because, from the National Statistics Agency data, the number of workers in West Pasaman continues to increase. Patchouli oil derivative industry in West Sumatra can anticipate if the amount of production in the future will increase. At the same time, foreign demand and selling prices decline. This processing plant can accommodate the results of West Sumatra patchouli oil, and farmers do not suffer losses if the world patchouli oil prices go down.

Based on Figure 6, the number of requests tends to be higher than production. The results obtained have been validated to Expert. Experts taken in this study are collectors and exporters by showing them the results of this study, Expert confirmed the results of this study, the possibility of production would look lower than demand for the next few years. Indonesia, as the biggest importer of patchouli oil in the world, but the world accepts not all of Indonesia's patchouli oil production. It suspected that the quality of West Pasaman patchouli oil does not meet the standards. The Patchouli Alcohol content of Indonesian patchouli oil mostly <31%, whereas the ISO standard requires over 31% (Setiawan, 2013). Quality is one that must be maintained to maintain the stability of the sales level (Baoshan, 2017). In addition to designing strategies, the government must disseminate to local communities the importance of quality. Farmers need training and training on quality so that the demand for patchouli oil in West Pasaman increases.

4. Conclusion

The patchouli oil industry would have many advantages for the surrounding community if it developed adequately. According to data from the Indonesia statistic center 2018, the amount of patchouli oil production in West Sumatra tends to decrease for the last five years and causes low productivity. This study aims to identify the supply chain, the gap analysis between the amount of patchouli oil production and demand for the next few years in West Pasaman. Prediction of the amount of production and demand for patchouli oil made as an input in formulating a strategy for developing patchouli oil agroindustry in the future. Comparison between the amount of patchouli oil production and the number of demand for patchouli in West Pasaman tend to fluctuate from 2018 until 2025.

This research has successfully demonstrated the difference between the amount of production and demand for patchouli oil in the next few years. Simulation results show that the amount of patchouli oil demands not every year to be fulfilled by collectors. In 2018 and 2019, overseas demand has not been able to achieve by patchouli oil production in West Pasaman, while 2020 to 2022 predicted order met well. Furthermore, the following year the request has not been fulfilled adequately. The dynamic system model for forecasting the number of patches demand in this study was made based on the number of planted areas in recent years. Based on simulations Increasing the amount of production can be done by adding patchouli planting areas in West Pasaman. West Sumatra has the opportunity to establish the patchouli oil derivative industry in West Pasaman. The government can take steps to develop a patchouli oil derivative plant in anticipation of demand, and the price of patchouli oil experienced a decline. This processing plant can accommodate the production of West Sumatra patchouli oil, and farmers do not suffer losses if the world patchouli oil prices go down. In addition to designing strategies, the government must disseminate to local communities the importance of quality. Farmers need training and training on quality, so that the demand for patchouli oil in West Pasaman increases.

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