Applying system dynamic for predicting the strengths, weaknesses, opportunities, and treats of Patchouli Oil Agroindustry in West Sumatra

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Abstract. The patchouli oil agroindustry is one industry that has the potential to be developed in West Sumatera. This study aims to analyze the future condition of the patchouli oil agroindustry in West Sumatera. As an initial step of the formulation strategy for developing patchouli oil agroindustry in West Sumatra. This study conducted a SWOT analysis using a dynamic system approach. The system dynamic is very suitable for the patchouli oil agroindustry's design development model because of the complex system. Other studies that have been conducted with SWOT analysis uses qualitative data obtained from corporate informants. In this study, SWOT data is collected based on the output derived from the dynamic system model. The system dynamics model run by using Powersim software with graphical output. Graphics can present internal and external conditions and the patchouli oil industry. Graphic trends that tend to increase will be categorized as strengths, while declining trends are classified as weaknesses. Based on the simulation results, there are six strengths, six weaknesses, two opportunities, and three threats of patchouli oil agroindustry forces in West Sumatra.

1. Introduction

Agroindustry is an industry of processing agricultural products (plants and animals), including physical processes and chemical transformation, storage, packaging, and distribution [1]. Vikash (2018) argues that agroindustry is an industry that produces products whose main ingredients come from plants and animals [2]. Agroindustry can be classified into four, which include; Agroindustry that processing of agricultural products, producing equipment and machinery, agricultural inputs like fertilizer, pesticides, herbicides, and agricultural sector services (supporting services) [3].

Patchouli oil agroindustry is one industry that has the potential to be developed in West Pasaman because it has a comparative advantage in procuring raw materials. This agroindustry can absorb a lot of labor, and its processing technology is quite simple so that it is quickly developed [4]. Raw materials are available sufficiently because the hilly geographical West Pasaman is very suitable for patchouli plants. In terms of processing, technology is relatively simple, processing traditional using drums heated with wood fuel. In terms of high employment and a transparent market, Indonesia is the world's largest patchouli exporter. Statistics show that the West Pasaman Regency has been the central patchouli oil-producing region in the West Sumatra for the past five years, followed by the Mentawai and Pasaman

districts [5].

Patchouli oil is a type of essential oil with a high fixation ability, so it is widely used in making perfumes, detergents, and hair conditioners [6]. Fixation materials are y necessary for fragrance products so that fragrance lasts longer. Essential oil is a type of oil that distilled from various kinds of plants such as lemongrass, fragrant roots, cloves, cinnamon, patchouli, roses, and other types of plants that give aroma [7]. Especially for essential oils obtained from the sources, stems, and leaves of plants extracted first [8][9].

Patchouli oil is a type of export commodity with the highest percentage compared to other essential oils. Indonesia supplies around 90% of the world's needs or 1600 tons per year [10]. The United States is the largest patchouli oil importer in the world. Patchouli oil needs in the United States come from several countries, especially countries in Asia and Europe. Besides being the largest patchouli oil importer globally, the United States is also the most significant oil market for Indonesia [11].

Based on previous research, patchouli oil agroindustry in Indonesia has not developed well because it fails to meet market opportunities, such as research conducted by Winarti (2005) and Purnomo (2007). Patchouli oil market opportunities are very wide open, while the patchouli oil agroindustry has not met the market demand optimally [14]. Based on research conducted by Rahmayanti (2018) and Rahmayanti (2019), the amount of patchouli oil production in West Sumatra last year has continued to decrease [29][30]. Reducing patchouli oil production is also supported by the National Statistics Agency data 2019 [31]. For this reason, it is necessary to start increasing the amount of patchouli oil production in West Sumatra. The developed agroindustry strategy must be by the characteristics of each agroindustry. The management strategy stages are strategy formulation, strategy implementation, resource implementation, and strategy evaluation [32]. Strategy formulation: includes activities to develop the organization's vision and mission, discuss opportunities and challenges of external organizations, determine the strengths and weaknesses of internal organizations, develop long-term organizational goals, make alternative strategies for the organization, and choose the specific approach at the initial stage of structuring the plan, internal and external analysis of the company done.

SWOT analysis organizes strengths, weaknesses, opportunities, and threats into a ranked list. Strengths and Weaknesses are internal come from internal agroindustry. Things that the owner can control and can change. Opportunities (opportunities) and Threats (threats) are external things that affect business or things outside agroindustry in a broader market. The owner can take advantage of opportunities and protect from dangers, but they cannot change them.

Various studies have been done in the development of agroindustry using SWOT analysis. Gu Wan-rong (2013) conducted a SWOT analysis to obtain a strategy for developing the corn industry in China in Heilongjiang Province [22]. Evalia (2015) has reviewed the plan of developing palm sugar agroindustry in Lareh Sago Halaban District with the SWOT method [33]. In the SWOT analysis, it is using qualitative data from company informants. In contrast to research using SWOT analysis, this study conducted a SWOT analysis with a quantitative approach. SWOT is interpreted based on the dynamic system output that has been designed for the development of patchouli oil agroindustry in West Sumatra.

This study aims to analyze the conditions of patchouli oil agroindustry in West Sumatra. The analysis was carried out by determining the strengths, weaknesses, opportunities, and threats of patchouli oil agroindustry in West Sumatra. It is an initial step in developing the strategy for developing patchouli oil agroindustry in West Sumatra. The analysis will do using system dynamics. System dynamics is a method used to describe, model, and simulate a dynamic system (from time to time continually changing). In the system dynamic, it also thinks systemically. It means that it is not just one central part of solving a problem, but its effects on all related to the problem [15]. Systems dynamics have advantages compared to other methods. Its model can provide more reliable estimates than the statistical model, provides a way to understand the causes of mechanical behavior, detect early changes in industrial structure and determine the factors that predict behavior significantly and sensitive [16]. Dynamic system models allow the determination of scenarios that make sense as input for the company's.

2. Materials and methods

2.1. Materials

Agroindustry is a broad subsector that covers upstream industries from the agricultural sector to the downstream sector. The upstream industry is an industry that produces farm equipment and machinery and industrial production facilities used in the process of agricultural cultivation. In contrast, the downstream sector is an industry that processes agricultural products into raw materials or goods that are ready for consumption or is a postharvest industry and processing of farm products. The three main areas of agroindustry activity, according to Austin 1992, ar

a. Marketing, marketing related to consumer preferences, market segmentation, demand forecasting, product pricing, distribution channels, and competitiveness are addressed.
b. Procurement, procuremen related to the relationship between the stages of production and processing, the method of managing the flo raw materials from the land to the factory.
c. Process, factors related to processing and technology selection issues, plant location, inventory management, processing inputs, and operational considerations.

Many previ s studies have been carried out related to the development of agroindustry. Some other research on agroindustry development can be seen in table 1.

2.2. ethods

The stages carried out in this study are:

1. Surveys, interviews related to patchouli oil production stages starting from the supply of raw materials to exporters
2. Designing a patchouli agroindustry system based on surveys and interviews conducted
3. esigning a stock-flow diagram (SFD) as one step in creating a system dynamics. SFD is designed in more detail than Causal Loop Diagrams (CLD) because it contains mathematical logic. In this study, five SFDs were intended, namely the patchouli plantation subsystem, the farmer's subsystem, the intermediary trader subsystem, the collector trader subsystem, and the exporter's subsystem.
4. The next step is running the program. The program is created using Powersim. B re the program run, they are ensuring that the application has been validated and verified. Dynamic system verification can be done with the Powersim software itself. Powersim Studio 2005 software has fulfilled the needs of automatic and real-time verification. The red question mark on the SFD identifies an error in the program. Errors can occur due to syntax or logic between incorrect variables. Validation in this study was done by checking the factors that influence agroindustry development that has been included in each Powersim output. This process is done by asking the opinions of experts. In this study, seven experts were selected, consisting of practitioners and academics.
5. Output analysis. Powersim output will be categorized into strengths, weaknesses, opportunities, and threats (SWOT). Graphic trends that tend to increase will be classed as strengths while declining trends are classified as weaknesses.

The data consists of primary and secondary data, primary data obtained through interviews and surveys with farmers, suppliers, and traders, while the primary data collected from the Central Statistics Agency.

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Table1. Agroindustry Development Research.

Researcher	Topic	Objective	Object	Tools	Development Aspects
Suryaningrat (2016)	Procurement of raw materials in managing the agroindustry supply chain of fruit processing in Indonesia	Evaluate current conditions of supply chain management procurement systems in Indonesia Fruit processing industry	Fruit processing agroindustry	Correlation analysis	Supply
PisaniadanScrocco (2016)	New business opportunities for farmers in Peru	Comparing new business opportunities such as the cultivation of asparagus, avocados, oranges with current agriculture namely cotton	Farmers in Peru	Making scenarios and analyzing sensitivity	Supplier
	Influencing political situation Policy, stability	Determine the effect of situation instability on import base	*Import Base Industry*		Policy
Machfoedz (2015)	On the development of agro-industry in Indonesia.	Industry and agro-based industry	*Agro Base Industry*	Literature review	
Ginting (2015)	Improve agro-industry performance through empowerment entrepreneurs and resources	Design a conceptual model to improve agro-industry competitiveness in Indonesia	Agro-industry sector	Literature review	Marketing, product innovation Technical
Gu Wan-rong, et al (2013)	Developing a strategy for corn agroindustry in China	Stimulate the development of the corn industry in Heilongjiang Province, increase the capacity of wheat production, as well as economic growth and increase the income of local farmers.	Wheat Agroindustry	SWOT analysis	
Pongchanun (2017)	Paper industrydevelopment strategy	Determining strategies to deal with global climate change and environmental challenges taking place in the paper processing industry, much traditional pulp and paper industries are required to create new business opportunities.	The pulp and paper industry	*Dynamic capabilities approach*	Organization Management
Teresa, et al (2017)	Improve food security governance in Mexico	Identify, describe, and analyze elements of food security governance in Mexico.	Food industry	Literature review	Supply, Technical
Augustine (2010)	Challenging for the corn seed industry in South Africa	Increased corn seed production	Corn seed industry	Literature review	Supply
Ferreira, et al (2016)	It is increasing the competitiveness of citrus agribusiness	Integrated production planning to increase competitiveness	Citrus agribusiness	System dynamic	Technical
Supriatna, et al (2004)	Development of clove leaf oil agroindustry	Analyze the initial planning system of an essential oil refining agroindustry from clove leaves in the North Sulawesi region, and analyze its feasibility from the technical aspects, management, and aspects financially	Clove leaf oil agroindustry	Plant layout design and econometric methods	Technical, management, financial
Indrawanto and Mauludi (2004)	Patchouli Industry Development Strategy Indonesia	Determine the development strategy for the Indonesian patchouli oil industry so that Indonesia can more enjoy the added value of the patchouli oil industry as a significant producer	Patchouli oil industry	Financial analysis	Financial

3. Results and discussion

The system will divide into five subsystems based on actors involved in the patchouli oil supply. The subsystems are patchouli plantation subsystems, patchouli farmers subsystems, intermediary trader subsystems, collector trader subsystems, and exporters. The addition of the patchouli planting area depends on the demand for patchouli in West Pasaman. Unfortunately, there are no specific data about the need for patchouli in West Pasaman. In this research, patchouli in West Pasaman is predicted based on patchouli oil production in the last few years, coupled with a commitment to increase patchouli oil production from the government in a certain percentage. The addition of new planting areas will undoubtedly impact the decline in agricultural land and plantations in West Pasaman. Patchouli plants that are newly planted will increase the size of patchouli plants that have not been produced even though the percentage does not reach one hundred percent. There are several percent of patchouli affected by pests. Increased pest infestation also results in a decrease in patchouli planting areas. Patchouli plants that produce after a few years will grow the patchouli field that does not provide, so rejuvenation needs to be done. In addition to the area of the plant that does not produce, rejuvenation is also influenced by pest attacks.

Furthermore, patchouli plants that have undergone rejuvenation will increase patchouli planting areas that have not been produced. And so on so that it forms a cycle. Patchouli planting area will increase the amount of harvest in the form of wet patchouli. However, the amount of patchouli harvest is also influenced by price. Farmers tend to harvest patchouli plants when the purchase price of patchouli oil is high at the farm level. If prices are low, farmers are more likely to leave them alone.

The amount of wet patchouli harvest, acquisition of patchouli, weather, patchouli seed types, and patchouli distillation equipment influence Patchouli oil production. Patchouli oil can be directly sold by farmers or stored as inventory. This condition usually occurs because of market prices. Farmers tend to hold patchouli oil for a while and will sell it if the purchase price of patchouli at the farm level is high. It increased acquisition and increase in patchouli oil inventory. Will result in an increase in the maximum amount of supply from farmers. The maximum supply amount and the amount of patchouli oil demand influence the amount of patchouli oil delivery. Increased demand will cause the number of shipments to increase and decrease in inventory. Besides the price, the increase in demand for patchouli oil also affects the wet patchouli harvest.

Slightly different from patchouli farmers, temporary traders in patchouli oil agro-industry are variable and tend to change. Most temporary traders only make this activity a side business. If the purchase price of patchouli oil rises, the number of intermediary traders will also increase. Increasing the purchase of patchouli oil to farmers will increase the stock and patchouli oil shipments. The longer the storage time for patchouli oil, the amount of patchouli oil stocks in intermediary traders will also increase.

Collecting traders will get patchouli oil supplies from farmers and intermediary traders. Collecting traders have the maximum quantity to send to exporters because they have stock. The amount of stock and the number of demand influence the amount of patchouli oil shipment to exporters.

In this study, foreign demand assumes the amount of patchouli oil exports. Increasing it will cause an increase in the amount of patchouli oil shipments. Increasing the amount of patchouli oil shipments has a positive relationship with the amount of patchouli oil order to the collector level. Increased shipping will also reduce the amount of storage and storage time. However, an increase in patchouli oil orders to intermediary traders over time causes an increase in inventory. This condition happens if the purchase price of patchouli oil in the world has decreased. Figure 1 shows the SFD of Patchouli Oil Agroindustry in West Sumatera.

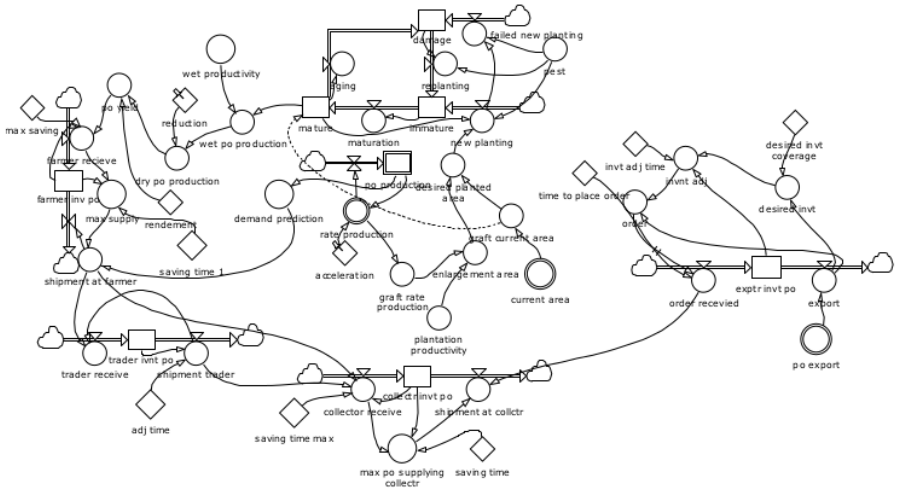
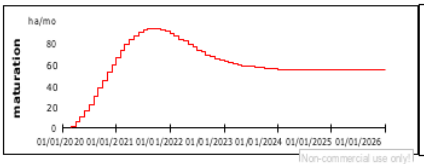
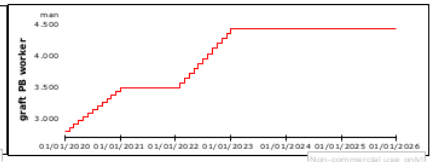


Figure 1. SFD of Patchouli Oil Agroindustry.

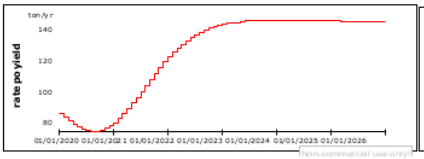
The next stage is to carry out the validation and verification process. In this study, the SFD was free from mistakes because no question marks were found; therefore, it concluded that the program had verified. Validation does through expertise. They will check whether all factors affect patchouli oil agroindustry in the design of the system dynamics model. From the results of testing seven experts, the model is valid because it contains all the factors that influence patchouli oil agroindustry development in West Sumatra. The program is running for the next six years, from 2020 to 2026. The results of the dynamic system output can be seen in figure 2.



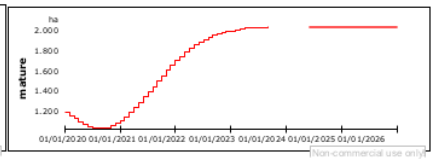
(a) Simulationo of Patchouli Productive Area Number



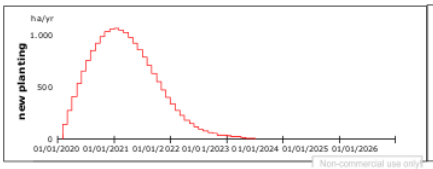
(b) Simulation of Worker Number



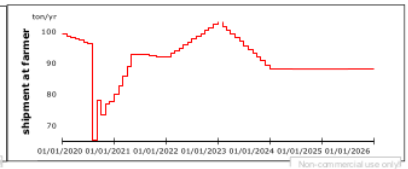
(c) Simulation of Patchouli Oil ProductionNumber



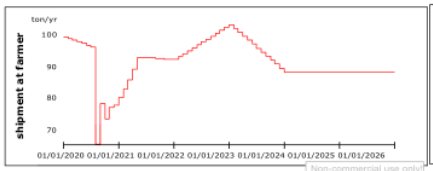
(d) Simulation of Planting Area Number



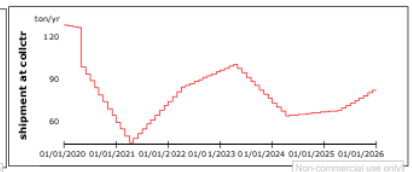
(e) Simulasi of New Planting Area



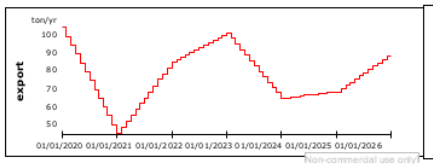
(f) Simulation of Selling Product at Farmer Level



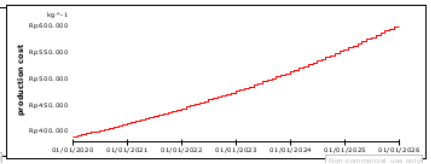
(g) Simulation of Selling Product at Intermediate Level



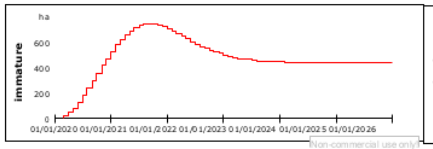
(h) Simulation of Selling Product at Collector Level



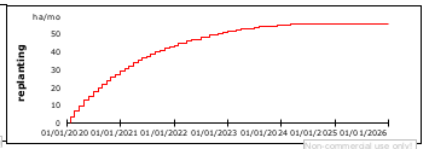
(i) Simulation of Ptachouli Oil Export Number



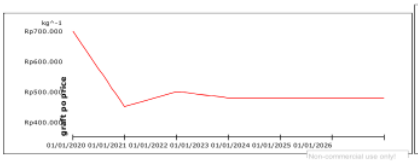
(j) Simulation of Patchouli Production Cost at Farmer Level



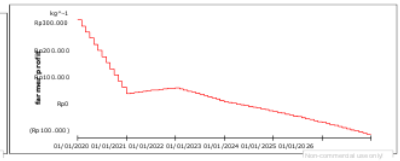
(k) Simulation of Non Productive Area



(l) Simulation of Replanting Area



(m) Simulation of Selling Price at Farmer Level



(n) Simulation of Profit at Farmer Level

Figure 2. Output System Dinamics from Powersim Software.

Based on Figure 3(a), the number of patchouli plants ready to be harvested has increased from 2020 to 2022, for the following year, the number of patchouli productive areas has decreased slightly. In contrast, for the next few years, it tends to be stable. Patchouli's prolific area trend for the next few years is relatively stable. The number of patchouli plants ready to be harvested is one of the strengths

for agroindustry development. The guaranteed supply of raw materials in wet patchouli is available in increasing quantities and is relatively stable.

Figure 3(b) shows that the number of workers continues to increase from 2020 to 2023, while the following years are relatively stable. The existence of adequate human resources is one of the factors driving the development of patchouli oil agroindustry. In terms of education level, based on data from the Central Statistics Agency 2018, the number of residents of West Pasaman who have taken tertiary education has increased every year. The increasing number of college graduates can be an indicator of the workforce's ability in West Pasaman to increase. The existence of resources is one factor in the industry [34][35].

The amount of patchouli productive area is directly proportional to the amount of patchouli oil produced. Thus, the amount of patchouli oil production in the West Pasaman region for the next few years tends to increase and is relatively stable. Increasing of patchouli production means that this is one factor that is a force for the development of patchouli oil agroindustry. Raw materials are the most critical factor for the sustainability of industry [36][37].

The total patchouli planting area is the total number of patchouli planting areas currently available in West Pasaman, both productive and non-productive. Figure 3(d) presents the total patchouli planting area for the next few years. The total patchouli planting area has increased in the first three years, while the following years are relatively stable from the simulation results. Increasing the number of patchouli planting areas is one of the strengths of patchouli oil agroindustry in West Pasaman. Patchouli's total planting area is one indicator that can guarantee the availability of patchouli oil raw material stock in West Pasaman.

Figure 3(e) shows that the patchouli planting area at the beginning of the first year has increased. Furthermore, it has decreased. In 2023, the number of new planting areas will be zero. This condition means that there is no opening of a new planting area for patchouli. Patchouli production for 2023 and the following year only relies on the rejuvenation of existing land. The patchouli planting area is one of the weaknesses for the patchouli oil agroindustry in West Pasaman.

From the simulation results seen between 2020 and 2021, the number of shipments has decreased steeply. This condition is possible because the amount of patchouli inventory at the collector level is still sufficient to meet exporters' demand. At the same time, exporters also have supplies to reach the foreign market. Another factor that triggered the absence of buying and selling transactions was the amount of patchouli oil exports, which declined because Indonesia's position, especially West Pasaman, as the world's largest patchouli oil exporter, has been replaced. Patchouli oil sales patterns at the farm level tend to be unstable and decline. The decline can be a weakness and inhibit the development of the patchouli oil agroindustry in West Pasaman.

The amount of patchouli oil sales at the collectors level tends to fluctuate. Patchouli oil sales decreased from 2020 to 2021. Then it increased the next two years and so on to form an up and downtrend. The fluctuation of patchouli oil sales at the level of intermediary traders was affected by the demand from exporters. This indefinite amount of order has become a weakness in the development of the patchouli oil agroindustry. Patchouli oil exports tend to fluctuate in the next few periods. The same is the case with the number of exports a few years before. Unstable and fluctuating export conditions are one of the threats to the development of patchouli oil agroindustry.

Production costs consist of fixed and variable costs. Based on historical data from various components of production costs, Production costs histories an increase every time. Figure 39(j) presents an increase in production price, which is linear over time. Based on the calculation of the current production cost, the cost of production is still under IDR 400,000/kg. This condition means that farmers can still benefit from seeing the current patchouli selling price. But if the situation of rising costs always occurs while the purchase price of patchouli at the farm level does not experience an increase, then in the future, it is certain that farmers will not benefit. The rise in production prices is undoubtedly a weakness as well as a barrier to patchouli oil agroindustry.

The purchase price at the farm level is predicted based on patchouli oil costs in recent years. As shown in Figure 3(m), patchouli oil prices only experienced an increase in the early years. In the following years, it tends to decrease and be stable. From interviews with farmers, it was found that patchouli oil prices often ranged between IDR 400.000 to IDR. 500,000, only in specific periods of a sudden increase and then decrease again.

There is no domestic oil demand in West Pasaman because collectors only sell patchouli oil to exporters located in Padang or Medan. In this study, the number of domestic patchouli oil demand for the next few years is assumed to be non-existent because there is no patchouli oil derivative industry in West Sumatra. The absence of a domestic market for patchouli in West Pasaman could be one of the

opportunities to establish the patchouli oil derivative industry.

The profit of patchouli oil sales depends on the purchase price of patchouli oil and patchouli oil production costs. The rising production costs and the relatively low and stable patchouli oil rate have resulted in a downward trend in profits. The simulation results in Figure 3(n) predict that in 2023 farmers will not benefit and even the following year, farmers will suffer losses. The decline in farmers' profits is a weakness in the development of patchouli oil agroindustry in the future. For this reason, the government must ensure participation in controlling patchouli purchase prices at the farm level. If the increase in the number of goods for production is assumed to follow historical price increases and the selling price of patchouli oil also follows historical data, from the simulation results, it appears that farmers will not benefit for the next few years. This simulation results can be a picture for the government to determine the strategy that should be done in the matter of the benefits of patchouli farmers.

4. Conclusion

This study conducted a SWOT analysis using a dynamic system approach. The system dynamic is very suitable for the patchouli oil agroindustry's design development model because of the complex system. Other studies that have been conducted with SWOT analysis uses qualitative data obtained from corporate informants. In this study, SWOT data is collected based on the output derived from the dynamic system model. The system dynamics model run by using Powersim software with graphical output. Graphics can present internal and external conditions and the patchouli oil industry. Graphic trends that tend to increase will be categorized as strengths, while declining trends are classified as weaknesses.

This research can analyze the internal and external conditions of the patchouli oil agroindustry in West Sumatra. This research has investigated the strengths, weaknesses, and threats of patchouli oil agroindustry development in West Sumatra. Based on the simulation results, there are six strengths, six weaknesses, two opportunities, and three threats of patchouli oil agroindustry forces in West Sumatra. These strengths are the increasing patchouli productive area, increasing patchouli oil production, the number of labor has tended to grow, increasing the total planting area, increasing the unproductive planting, and increasing the patchouli replanting area. The weakness of patchouli oil agroindustry in West Sumatra is the decreasing patchouli planting area and decreasing patchouli oil sales at the farm level. Other factors for deficiency are reducing the number of patchouli oil shipments at the level of intermediary traders, reduce the amount of patchouli oil shipments at the level of collector traders, production costs tend to fall increase, farmers' profit tends to decrease. Opportunities for developing patchouli oil agroindustry in West Sumatra are domestic sales none and he market available well. The threat of patchouli oil agroindustry development in West Sumatra is the world's unstable patchouli oil price, the number of patchouli exports tends to fluctuate, and patchouli purchase price oil in farmers does not increase.

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