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Analysis of Palm Oil Production Planning for Biodiesel Needs in North Sumatra with a Dynamic System

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Abstract: Palm oil has become a leading product in the plantation business in Indonesia. Currently, Indonesia has become the country with the largest palm oil production capacity in the world. With this production capability, the opportunity to diversify energy made from palm oil is very possible. The analysis of this study was carried out using secondary data to find out the extent of the potential of palm oil as the main source of biodiesel raw materials in Indonesia. The method used is a dynamic system. System Dynamics (SD) is a computer-assisted approach to analyzing and solving complex problems with a focus on policy analysis and design. System Dynamics is very suitable for dynamic simulations in making mathematical planning analyzes of palm oil production for planning North Sumatra's biodiesel needs. The results of the analysis state that with the production and expansion of oil palm land very massive, energy diversification is a relevant step and very feasible. The role of the government through the export levy tariff policy also determines palm oil consumption for the benefit of the domestic market.

Keywords: *Palm oil; Biodiesel ; CPO*

INTRODUCTION

Oil palm is a plantation crop that has a dual function, in addition to crops with high economic value, a source of income, employment, non-oil and gas export income, as one of the basic necessities and others. In terms of environmental impact, biodiesel is also known to be relatively clean from pollutant emissions (Pasha & Suryani, 2017). The use of biodiesel is expected not only to reduce the amount of diesel demand which can have an impact on reducing the government's burden on subsidies, but also to support environmentally friendly and sustainable energy utilization programs. Opportunities for the use of biodiesel as an energy source in the future will be analyzed based on projected energy needs and projected biodiesel needs including the cost of biodiesel in Indonesia in the future. Based on these results, it can be analyzed the need for oil palm plantations and the production of palm oil or *crude palm oil* (CPO) as a raw material for biodiesel in the future (Shintawaty, 2016).

Crude Palm Oil (CPO) which is processed into biodiesel is not considered sufficient to meet energy demand. Therefore, in meeting the energy demand, the government is trying to optimize jatropha *curcas* as a national program that can be processed into biodiesel. This jatropha plant will be produced by farmers in rural areas not only to provide energy supplies but is also expected to be able to accommodate unemployment and reduce poverty and become a pollutant-free energy (Prakash, 1998).

In meeting the demand for Biodiesel in the planning of North Sumatra's palm oil needs, an integrated planning is needed and optimizing all existing *stakeholders*. The government's ideals enshrined in the 2005-2025 energy blueprint will disappear when it is not followed by hard work by involving the community as users and producers of renewable energy (Husaini & Yusep, 2004).

Palm oil is the most potential biodiesel raw material based on the amount of supply and price compared to other vegetable oils. Palm oil has a productivity of 3.62 tons/ha/year, or 5.3 times greater than rapeseed oil, 7.8 times greater than sunflower oil, 9 times larger than soybean oil. In addition to high productivity, the price of palm oil is cheaper than other vegetable oils, namely in the range of 1,238.57 – 1,077.78 USD/MT from January 2011 to August 2021, therefore, palm oil is very promising as a raw material for biodiesel production. In addition to palm oil, the most widely used vegetable oils in the biodiesel industry are soybean oil and rapeseed, with a percentage of 26%, and 16% to the world's total biodiesel production of 41.2 million tons (Instruksi Presiden RI, 2006).

The development of biodiesel in Indonesia is driven by the Mandatory Biodiesel Policy through the Minister of Energy and Mineral Resources Regulation No. 32 of 2008 concerning the supply, utilization, and trading of biofuels as alternative fuels. Indonesia is developing a biodiesel industry made from palm oil because palm oil commodities have the greatest potential to be processed into biodiesel in Indonesia. The Government of

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Indonesia made the third amendment to the mandatory biodiesel policy through Minister of Energy and Mineral Resources Regulation No. 12 of 2015 by increasing the minimum obligation to use biodiesel as a fuel oil mixture to 30 percent. The Government of Indonesia shows its seriousness in developing the biodiesel industry by issuing the Minister of Energy and Mineral Resources Regulation No. 26 of 2015, namely biodiesel biofuel business entities are entitled to obtain biodiesel financing from the Oil Palm Plantation Fund Management Agency (BPDPKS) (Kementerian Lingkugan Hidup Indonesia, 2005).

Therefore, biodiesel production, which shows an increasing trend, cannot necessarily be used as an indicator of the success and mandatory sustainability of biodiesel (Sa'adah et al., 2017). The blending rate set by the government in the mandatory biodiesel policy is quite progressive in the stages of increase (Zulfikar et al., 2023). Based on this description, the problem formulation is how to analyze palm oil production planning for biodiesel needs in North Sumatra and what are the results of the analysis of palm oil production planning for biodiesel needs in North Sumatra.

LITERATURE REVIEW

Production Planning

Planning is basically one of the many planning concepts that have developed, in planning it is one of the management functions. Every expert in stating management functions does not fail to include planning as one of the functions and this function is always placed in first place. (Marciano & Gladis, 1998)provides an understanding of planning as follows: "Planning is a disciplined effort to make important decisions and actions that shape and guide how an organization (or other entity) becomes, what the organization (or other entity) does, and why organizations (or other entities) do things like that. Whittaker in (Soejani, 2020) suggests 10 steps needed to formulate planning, namely:

a. Formulate the organization's mission (mission)
b. Formulate the organization's vision (vision)
c. Develop organizational values (values)
d. Conduct internal analysis (internal analysis)
e. Conduct external analysis (external analysis)
f. Formulate assumptions (assumptions)
g. Develop strategic analysis and choose a strategy (strategic analysis and choice)
h. Formulate key success factors (critical success factors)
i. Formulate organizational goals (goals)
j. Formulate operational targets and strategies (corporate objectives and strategy)

Production planning is planning about what and how many products will be produced by the company concerned in the coming period. Production planning is part of operational planning within the company. When preparing production planning, the thing that needs to be considered is production optimization so that the lowest cost level can be achieved for implementing the production process. A literature review is a critical, analytical summary and synthesis of the current knowledge of a topic. It should compare and relate different theories/research, findings, and so on, rather than just summarize them individually. It should also have a particular focus or theme to organize the review. In this section, the researcher can describe some of the related previous studies. Researchers can review the gaps in the research, then it can be used as a basis for research to be carried out.

Biodiesel

The use of Biodiesel which is made from biological sources raw materials or biomass to fuel motor vehicles has technically been done for a long time, but since the discovery of cheaper petroleum or petroleum, the development of the use of these two renewable energy sources has been hampered. Bio-diesel through transesterification from vegetable oil has been carried out since early 1853 by E. Biodiesel has become an alternative fuel to replace diesel in several countries, such as Malaysia, the Philippines, Europe and America. It can be used as an alternative fuel to accompany diesel. Moreover, the availability of raw materials is adequate. Crude palm oil (CPO) is a leading export commodity for Malaysia and Indonesia as well as being the largest CPO supplier in the world. According to Oil World, in 2000, Malaysia supplied 51% while Indonesia supplied 29.8% of CPO from world demand (Prayogi, 2022).

Dynamic Systems

System Dynamics (SD) is a computer-assisted approach to analyzing and solving complex problems with a focus on policy analysis and design. Initially called Industrial Dynamics (Du & Zhong, 2021), then developed by Tim Jay W. Forrester at the Massachusetts Institute of Technology. SD is based on engineering control and management: the approach uses a basic information perspective, feedback and delays to understand the dynamic

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behavior of complex physical, biological, and social systems (the dynamic behavior of complex physical, biological, and social systems). (Suci et al., 2021) defined Industrial Dynamics as the study of the characteristics of feedback information in industrial activities showing how the enlargement of organizational structure (in policies) and time delays (in decisions and actions) are interconnected in influencing the success of the company.

System dynamics has been applied to a wide range of problems, including in the fields of economics, management and public policy, health and biology, energy and the environment, development in natural and social knowledge, dynamics decision making, software engineering, supply chain management, and especially with In preparing this final project, System Dynamics is very meaningful in providing a contribution to the biodiesel utilization model as part of a renewable energy and environmental model. System Dynamics is very suitable for dynamic simulations in making mathematical planning analyses of palm oil production for planning North Sumatra's biodiesel needs (Rachma, 2020).

METHOD

This research uses a type of quantitative research for research by collecting data that can be measured by mathematics. In this thesis research, the researcher uses a quantitative method. The quantitative method based on (Sugiyono, 2019) is a research method based on the philosophy of positivism, used in populations or subsamples. Data collection with quantitative/statistical research instruments Quantitative methods must test predetermined hypotheses.

To support this research, the data source used is primary data. Primary data was obtained from the results of interviews and documentation with PTPN III employees. In this case, there are 2 variables, namely: The results of the mathematical planning of oil palm needs and the variables of the results of the planning of biodiesel needs. The research requires several stages, namely the following:

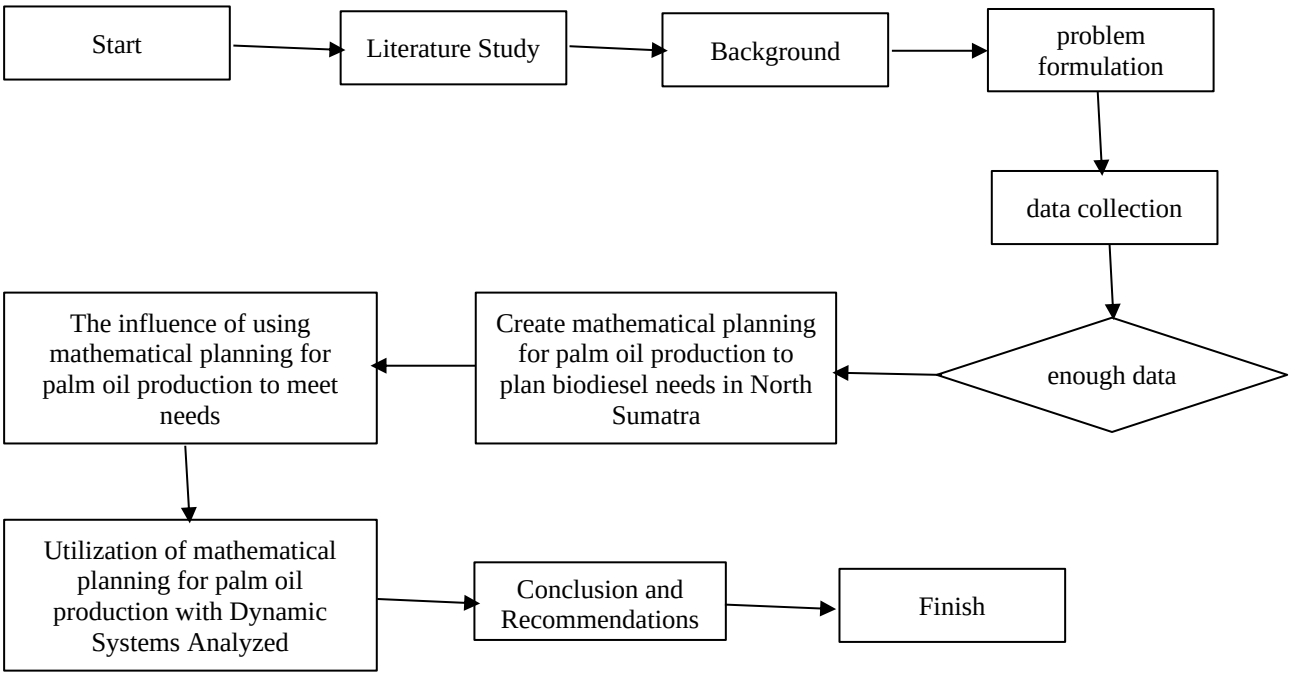

Fig. 1 framework of thinking

RESULT

In This case In this study, data collection was carried out by collecting data on palm oil production and biodiesel needs in 2022. The production data and needs are presented in table 1. The result, of demand forecasting will be used as production planning for the future. Production planning has also been prepared aimed at meeting the needs of biodiesel. So that what is needed by biodiesel can be fulfilled and the goal of producing profits can be realized.

Table 1. Oil Palm Production Data 2022

Month	Palm Oil Production (Tons)	Biodiesel Needs (Kiloliter)
January	3.892	810.000
February	2.123	900.000

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March	4.123	900.000
April	35.000	1.600.000
May	28.500	1.308.000
June	14.280	980.000
July	23.800	1.123.000
August	8.230	950.000
September	4.200	967.000
October	18.400	1.350.000
November	25.000	1.500.000
December	4.900	760.000
TOTAL	172.448	13.148.000

The results of demand forecasting will be used as production planning for the future. Production planning has also been prepared to meet biodiesel needs. So that the needs of biodiesel can be met and the production goal of making a profit can be realized. With accurate and correct demand forecasts, production planning for this year can be estimated. Below is presented historical data on palm oil production data for the last 1 year.

Table 2. Palm Oil Production Volume (January-December 2022).

Month	Palm Oil Production (Tons)	Scale	Xy	X
January	3.892	0	0	0
February	2.123	1	2.123	1
March	4.123	2	8.246	4
April	35.000	3	105.000	9
May	28.500	4	114.000	16
June	14.280	5	71.400	25
July	23.800	6	142.800	36
August	8.230	7	57.610	49
September	4.200	8	33.600	64
October	18.400	9	165.600	81
November	25.000	10	250.000	100
December	4.900	11	53.900	121
Total	172.448	66	1.004.279	506

The table above is the historical data of palm oil production over the last 1 year. From this data, we can determine the needs that will be used as production planning in the future. The production plan that will be prepared will be able to meet the needs of biodiesel so as to get profits. Accurate demand forecasting can estimate production forecasting even though it is actually not absolute.

$$y = ax + b \qquad (1)$$

$$a = \frac{(\sum y)(\sum x^2) - (\sum x) - (\sum xy)}{n(\sum x^2) - (\sum x)^2} \qquad (2)$$

$$a = \frac{((172.448)(506) - (66)(1.004.279)}{12(506)(66)^2}$$

$$a = \frac{20.976.724}{26.449.632}$$

$$a = 0,79$$

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$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{12(1.004.279) - 66(172.448)}{12(506) - (66)^2}$$

$$b = \frac{669.780}{26.449.632}$$

$$b = 0,025$$

From the results of the demand forecast above, it can then be used for monthly sales forecasting using the seasonal approach method, namely the seasonal average method.

Table 4.3. Monthly Trend Increase in 2023

Month	Monthly Average	Periode Scale (x)	xy	X^2	Trend
January	3.362	-11	-36982	121	0
February	1.593	-9	-14337	81	16
March	3.593	-7	-25151	49	24
April	34.470	-5	-172350	25	32
May	27.970	-3	-83910	9	40
June	13.750	-1	-13750	1	48
July	23.270	1	23270	1	56
August	7.700	3	23100	9	64
September	3.670	5	18350	25	72
October	17.870	7	125090	49	80
November	24.470	9	220230	81	88
December	4.370	11	48070	121	96
TOTAL	166.088	0	111.630	572	

Calculating Season Variance

Seasonal Variation is a movement of data that goes up and down regularly and tends to repeat for less than 1 year. Seasonal variations are greatly influenced by the trend value in a certain period. Since the increase in the trend in January is equal to zero, then The monthly average sales for January are not affected by the Trend value at all.

$$Vm = rata - ratabulanan - trend \quad (3)$$

Table 4 Calculation of Seasonal Variance

Month	Monthly Average	Period Scale (x)	xy	y	Trend	Seasonal Variations
January	3.362	-11	-36982	121	0	3.362
February	1.593	-9	-14337	81	16	1.577
March	3.593	-7	-25151	49	24	3.569
April	34.470	-5	-172350	25	32	34.438
May	27.970	-3	-83910	9	40	27.930
June	13.750	-1	-13750	1	48	13.702
July	23.270	1	23270	1	56	23.214
August	7.700	3	23100	9	64	7.636
September	3.670	5	18350	25	72	3.598
October	17.870	7	125090	49	80	17.790
November	24.470	9	220230	81	88	24.382

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December	4.370	11	48070	121	96	4.274
TOTAL	166.088	0	111.630	572	616	165.472

Calculating the Seasonal Index

The season index is the value of seasonal variation each month expressed as a percentage of the average value of seasonal variants over 12 months. To calculate the season index, it is necessary to know the average value of seasonal variations each month.

Average seasonal variation

$$= \frac{165.472}{12} = 13.789$$

From the average seasonal variation above, then look for the seasonal index for each month. The following is the calculation of the seasonal index for each month.

$$\text{Season Index } \frac{variasi\ musim}{Rata{-}rata\ Variasi\ Musim} \qquad (4)$$

Table 5 Seasonal indices

Production	Monthly Average	Period Scale (x)	XY	X^2	Trend	Seasonal Variations	Seasonal Index
January	3.362	-11	-36982	121	0	3.362	24,38%
February	1.593	-9	-14337	81	16	1.577	11,44%
March	3.593	-7	-25151	49	24	3.569	25,88%
April	34.470	-5	-172350	25	32	34.438	249,74%
May	27.970	-3	-83910	9	40	27.930	202,55%
June	13.750	-1	-13750	1	48	13.702	99,37%
July	23.270	1	23270	1	56	23.214	168,35%
August	7.700	3	23100	9	64	7.636	55,38%
September	3.670	5	18350	25	72	3.598	26,09%
October	17.870	7	125090	49	80	17.790	129,01%
November	24.470	9	220230	81	88	24.382	176,82%
December	4.370	11	48070	121	96	4.274	30,99%
TOTAL	166.088	0	111.630	572	616	165.472	1.200

Production Planning

Production Planning is a description of the results of production planning. Production planning is an activity that does not stand alone in carrying out supporting activities for production planning. Because production planning includes planning the amount of production, and inventory needs. The following is a table of the final supply of palm oil in 2023.

Table 6 Final Preparation Oil Palm in 2023

Month	Ending Inventory 2023
January	3.362
February	1.593
March	3.593
April	34.470
May	27.970
June	13.750
July	23.270
August	7.700
September	3.670
October	17.870

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November	24.470
December	4.370

When a company sets the inventory level to:
1.Inventory at the beginning of the year = 4,900
2. Year-end inventory = 3,362

In table 7 below, it is explained that the total production planning acquisition in 2024 is 24,460 tons. For the months of January to December in 2024, the highest production value fell in April with a total of 116,964 tons, while the lowest production was in June with a total production of 557 tons.

Table 7 Palm Oil Production Planning Calculations for 2024

	Information				
Month	sale	Ending Inventory	Available inventory	Initial inventory	Production
January	819,6947	3.362	4.182	4900	718
February	182,1815	1.593	1.775	3.362	1.587
March	929,9519	3.593	4.523	1.593	2.930
April	86086,68	34.470	120.557	3.593	116.964
May	56652,64	27.970	84.623	34.470	50.153
June	13662,92	13.750	27.413	27.970	557
July	39174,47	23.270	62.444	13.750	48.694
August	4263,962	7.700	11.964	23.270	11.306
September	957,5996	3.670	4.628	7.700	3.072
October	23054,58	17.870	40.925	3.670	37.255
November	43267,32	24.470	67.737	17.870	49.867
December	1354,48	4.370	5.724	24.470	18.746

Total Production : 14.460 ton

Table 7. explains that the total planned production gain in 2024 is 24,460 tons. For January to December in 2024, the highest production value fell in April with a total of 116,964 tons, while the lowest production was in June with total production of 557 tons. From the results of this research and discussion, it is concluded that production plans in 2024, especially January to December, will fluctuate, more production does not necessarily mean good profits, but a small amount of production can minimize future losses so that we can see the situation and ongoing developments in needs. experienced insignificant changes and improvements.

DISCUSSIONS

System Dynamics (SD) is a computer-assisted approach to analyzing and solving complex problems with a focus on policy analysis and design. The dynamics or behavior of a system is defined by its structure and the interactions of its parts. The primary goal of dynamical systems is to understand how this behavior is generated through the use of qualitative and quantitative models and to use this understanding to estimate the consequences of policy changes to the system over time. In applying a dynamic system in the case of making a mathematical planning analysis for palm oil production for planning North Sumatra's biodiesel needs, it starts with production planning by predicting exact and correct needs, so production planning for this year can be estimated. From the results of demand forecasting, it can then be used to forecast monthly sales using the seasonal approach method, namely the seasonal average method. Then calculate the seasonal variance, which is a data movement that goes up and down regularly and tends to repeat itself in less than 1 year. Seasonal variations are strongly influenced by trend values in a certain period. Because the trend increase in January is equal to zero, the monthly average sales for January are not at all influenced by the Trend value. Then calculate the msiman index which is the seasonal variation value for each month expressed as a percentage of the average seasonal variance value for 12 months. Next is production planning. Production planning is an activity that does not stand alone and carries out supporting activities for production planning. Because production planning includes planning production quantities, inventory requirements. The total planned production gain in 2024 is 24,460 tons. For January to December in 2024, the highest production value fell in April with a total of 116,964 tons, while the lowest production was in June with a total production of 557 tons. From the results of this research and discussion, it is concluded that

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production plans in 2024, especially from January to December, will fluctuate, more production does not necessarily mean good profits, but a small amount of production can minimize future losses so that we can see the situation and ongoing developments in needs. experienced insignificant changes and improvements.

CONCLUSION

Based on the results of the study, the following conclusions were obtained: (1) To analyze the planning of palm oil production for biodiesel needs in North Sumatra was carried out by calculating the seasonal variance in 2022-2023, calculating the seasonal index so that a production plan was obtained (2) The results of the analysis of oil palm production planning for biodiesel needs in North SumatraThat the total production planning in 2024 is 24,460 tons. For the months of January to December in 2024, the highest production value fell in April with a total of 116,964 tons, while the lowest production was in June with a total production of 557 tons. From the results of this research and discussion, it is concluded that the production plan in 2024, especially from January to December, fluctuates, more production does not necessarily get good profits, but a small amount of production can minimize future losses in order to see the situation and development of needs that continue to change and increase insignificantly.

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