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Forecasting the Amount of Oil Palm Production in Simalungun Regency Based on Data for 2000-2019 Using Double Exponential Smoothing Method

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Abstract. Economic growth in our country comes from various sectors, one of which is the agricultural and plantation sectors. This sector plays an important role in generating a source of foreign exchange for our country after the oil and gas mining sector through its commodity exports. The data used by the author in this final project is secondary data from the Central Bureau of Statistics of North Sumatra regarding oil palm production in Simalungun Regency. Quantitative analysis is used to determine the amount of oil palm production in Simalungun Regency which is predicted in 2020, 2021, and 2022, involving production patterns from 2000 to 2019 Then based on the amount of production data, the data is processed using quantitative time forecasting methods. series, namely Double Exponential Smoothing one parameter from Brown, by looking at the resulting error value, namely the Mean Absoute Percentage Error (MAPE) value. Based on forecasting results, the amount of oil palm production in Simalungun Regency in 2020 is 467,295.15 tons, the amount of oil palm production in Simalungun Regency in 2021 is 501,766.48 tons, in 2022 it is 536,237.81 tons. So the production of palm oil in Simalungun Regency increases from year to year, but there are times when it decreases not so drastically, so it can be concluded that the production of palm oil harvests in Simalungun Regency is increasing.

Keyword: Double Exponential Smoothing Method, Forecasting, Oil Palm Production

Abstrak. *Pertumbuhan ekonomi di negara kita datang dari berbagai sektor, salah satunya sektor pertanian dan perkebunan. Sektor ini berperan penting dalam menghasilkan sumber devisa bagi Negara kita setelah sektor pertambangan minyak dan gas melalui ekspor komiditinya. Data yang digunakan penulis dalam tugas akhir ini adalah data sekunder dari Kantor Badan Pusat Statistik Sumatera Utara tentang produksi Kelapa Sawit di Kabupaten Simalungun. Analisis kuantitatif digunakan untuk mengetahui banyaknya jumlah produksi kelapa sawit di Kabupaten Simalungun yang diramalkan pada tahun 2020, 2021, dan 2022, dengan melibatkan pola produksi dari tahun 2000 sampai dengan tahun 2019 Kemudian berdasarkan jumlah data produksi tersebut, data diolah dengan menggunakan metode kuantitatif peramalan time series yaitu Double Exponential Smoothing satu parameter dari*

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Brown, dengan melihat nilai kesalahan yang dihasilkan yaitu nilai Mean Absoute Percentage Error (MAPE). Berdasarkan hasil peramalan, jumlah produksi kelapa sawit di Kabupaten Simalungun pada tahun 2020 adalah sebanyak 467.295,15 ton, jumlah produksi kelapa sawit di Kabupaten Simalungun pada tahun 2021 adalah sebanyak 501.766,48 ton, pada tahun 2022 adalah sebanyak 536.237,81 ton. Maka produksi kelapa sawit di Kabupaten Simalungun meningkat dari tahun ke tahun, tetapi ada saatnya menurun tidak begitu drastis, sehingga dapat disimpulkan produksi panen kelapa sawit di Kabupaten Simalungun meningkat.

Kata Kunci: *Metode Double Exponential Smoothing, Peramalan,Produksi Minyak Sawit*

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1. Introduction

Economic growth in our country comes from various sectors, one of which is the agricultural and plantation sectors. This sector plays an important role in generating a source of foreign exchange for our country after the oil and gas mining sector through its commodity exports. Each region has a different level of prosperity. These differences occur because of economic differences in the region concerned. An area with a prosperous condition can be because the area has a wealth of natural resources that other regions do not have, businesses in producing goods and services, as well as efficient government policies in advancingthe economy of the region concerned [1].

Simalungun Regency is one of the oil palm producing districts in North Sumatra Province. Simalungun Regency has been able to increase oil palm production every year. Starting from 2000 to 2019 the amount of palm oil production in Simalungun Regency has increased from 388,569.00 tons to 512,100.00 tons. One of the factors in increasing the amount of oil palm production is the processing of vacant land that was not previously processed by the community [2]. This condition shows that Simalungun Regency is a potential area to develop oil palm production. The amount of oil palm production in Simalungun Regency fluctuates, where there are unequal additions and subtractions every year. Fluctuating palm oil production will affect the economy of a region where there is a gap between the amount of production and the amount of demand [3].

To get good results, you must know the right forecasting method. The time series analysis forecasting method used to predict the value of exports and imports in solving this problem is to use the double exponential smoothing method, namely the one-parameter exponential smoothing method from Brown [4]. This method is a method discovered by Brown. The rationale for Brown's one-parameter linear exponential smoothing method is the linear moving average [5].

2. Related Work

2.1 Forecasting

Forecasting is a calculation analysis technique that is carried out with a qualitative or quantitative approach to forecast future events based on data references in the past. In forecasting, one of the most important things is the accuracy of forecasting, namely how to measure the suitability of a particular forecasting method for a given data set [4].

2.2 Forecasting Steps

The quality of the results of a forecast that is compiled is largely determined by the implementation process in its preparation. Good forecasting is forecasting that is carried out by following good preparation steps or procedures [4].

2.3 Smoothing Method

The smoothing method or smoothing is a forecasting method by smoothing past data, namely by taking the average of the values of several periods to estimate the value in the next several periods. The smoothing method is widely used to eliminate or reduce randomness from time series data [5].

2.4 Exponential Smoothing Method

So the time series analysis forecasting method used to predict the value of exports and imports in solving this problem is to use the double exponential smoothing method, namely the one-parameter exponential smoothing method from Brown [6]. This method is the method used by Brown The rationale for Brown's one-parameter linear exponential smoothing method is a linear moving average, because both single and multiple smoothing values lag behind the actual data. Forecasts that can be used in the implementation of Brown's one-parameter linear exponential smoothing are as follows:

1. Determine the value Smoothing first S_t'

$$S_t' = \alpha X_t + (1-\alpha) S_{t-1}' \quad (1)$$

2. Determining the value of Smoothing the second S_t''

$$S_t'' = \alpha S_t' + (1-\alpha) S_{t-1}'' \quad (2)$$

3. Determining the value of a constant period a_t

$$a_t = 2S_t' - S_t'' \quad (3)$$

4 . Determining the value of smoothing constant (b_t)

$$b_t = \frac{\alpha}{(1-\alpha)} (S_t' - S_t'') \quad (4)$$

5. Determine the value of forecasting (F_{t+m})

$$F_{t+m} = a_t + b_t(m) \quad (5)$$

Description:

m = Number of future periods that are predicted
S_t' = Exponential smoothing Single in t period
S_t'' = Exponential smoothing Double in t period
α = Exponential smoothing parameters $(0 < \alpha < 1)$
a_t, b_t = Smoothing constant
F_{t+m} = Forecasting result for the next m period

2.5 Forecasting Accuraty

Forecasting accuracy is a fundamental thing in forecasting, namely how to measure the suitability of a certain forecasting method for a given data set. Accuracy is seen as a refusal criterion to choose a forecasting method. In time series modeling from past data, it is possible to predict situations that will occur in the future, to test the truth of this prediction, accuracy is used. Some of the criteria used to test the accuracy of the forecast are:

a. ME *(MeanError)*/ Mean error

$$ME = \sum_{t=1}^{n} \frac{e_t}{n} \quad (6)$$

b. MSE *(MeanSquare*Error)/ Mean Squared Error

$$MSE = \sum_{t=1}^{n} \frac{e_t^2}{n} \quad (7)$$

c. MAE *(MeanAbsolute*Error)/ Mean Absolute Error

$$MAE = \sum_{t=1}^{n} \frac{|e_t|}{n} \quad (8)$$

d. MPE *(MeanPercentage*Error)/ Central Value Error Percentage

$$MPE = \frac{\sum_{t=1}^{N} PE_t}{N} \quad (9)$$

e. SSE (Sum Square Error) / Sum of Squares Error

$$SSE = \sum_{t=1}^{n} e_t^2 \quad (10)$$

f. MAPE *(Mean Absolute Percentage* Error)

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n} \quad (11)$$

The measure of forecasting accuracy is used to evaluate the value of the forecasting parameters. If X_t is the actual data for the period t and F_t is the forecast (or the value of a match) for the same period, then the error is defined as follows:

$$e_t = X_t - F_t \tag{12}$$

2.6 Mean Absolute Percentage Error (MAPE)

MAPE or absolute percentage error median value is the average of the overall percentage of error (difference) between the actual data with the value forcasting for MAPE calculating formula (13) is as follows:

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n} \tag{13}$$

Table 1. Value MAPE for the Evaluation of Prediction

Value MAPE	Accuracy of Prediction
MAPE ≤ 10%	High
10% <MAPE ≤ 20%	Good
20% <MAPE ≤ 50%	is still well used
MAPE>50%	Low

percentage of error is an error percentage of a forecasting:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right) 100\% \tag{14}$$

Description:

e_t = error in the period to-t

X_t = actual data for the period to-t

F_t = the value of the forecast period to-t

n = number of times period

3. Research Flow Chart

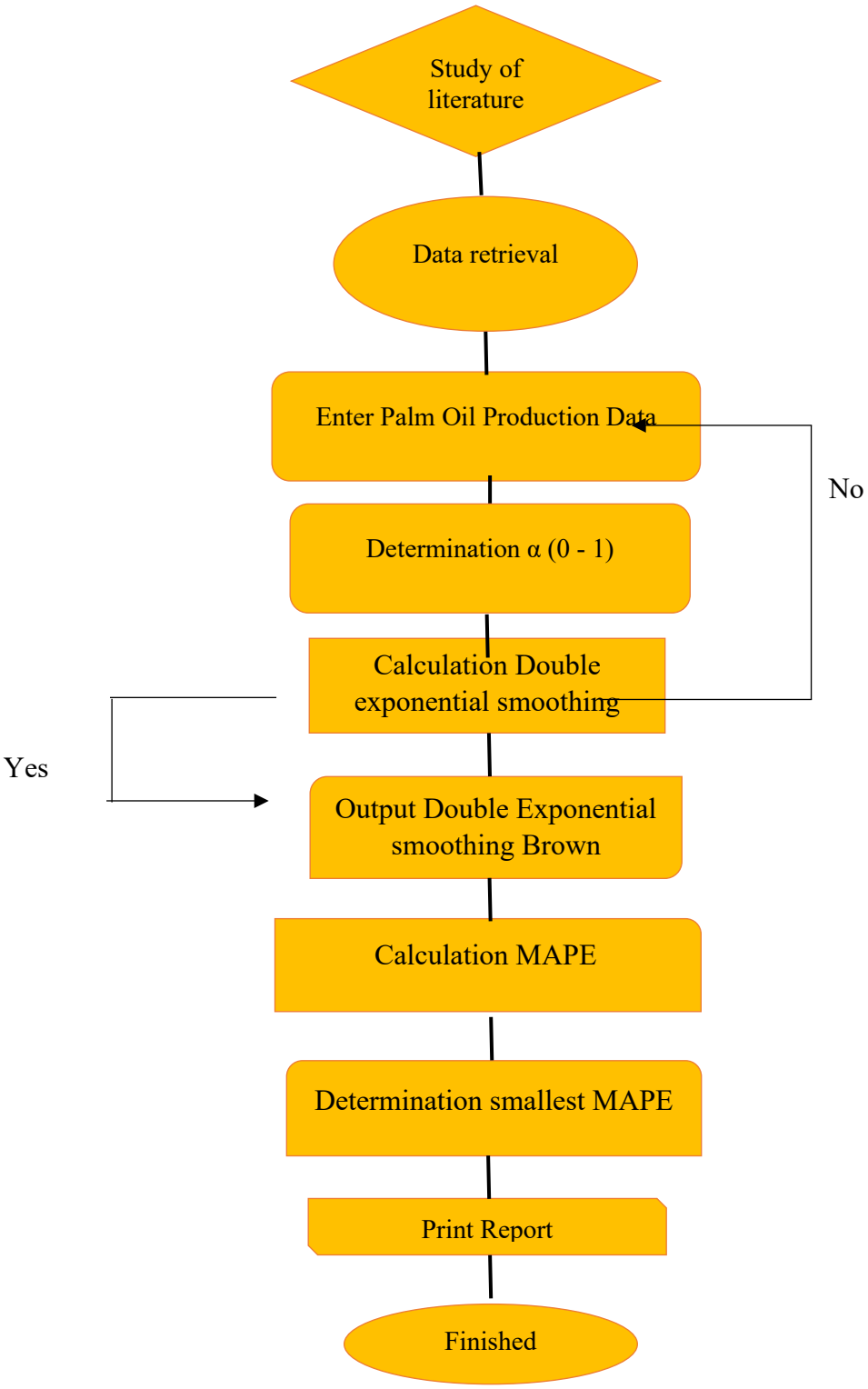

Figure 1. Research step

4. Result and Discussion

3.1 Data Collection

Data collection was carried out at the Provincial Central Statistics Agency (BPS) of North Sumatra, the data taken was the amount of oil palm production in Simalungun Regency in 2000-2019.

Table 2. Data on Total Oil Palm Production in Simalungun Regency 2000-2019

Year	Period	Production
2000	1	388.569,00
2001	2	498.316,00
2002	3	493.313,00
2003	4	494.761,00
2004	5	494.760,00
2005	6	502.665,45
2006	7	505.441,41
2007	8	490.304,27
2008	9	493.315,03
2009	10	111.010,59
2010	11	507.949,41
2011	12	508.970,15
2012	13	513.546,41
2013	14	522.721,59
2014	15	114.100,00
2015	16	43.781,82
2016	17	517.218,18
2017	18	547.209,05
2018	19	122.341,97
2019	20	512.100,00

Source : National Statistics North Sumatra

3.2 Method Analysis

Calculation of Palm Oil Production Data Using One Parameter Linear Exponential Smoothing Method from Brown

The forecast for the amount of production is as follows: Year 1 (2000):

S_t' = The amount of oil palm production in the first year (2000) was determined, which was 388,569.

S_t'' = The amount of oil palm production in the first year (2000) was determined, which was 388,569, because the t-1 data had not been obtained.

a_t = Undefined.

b_t = Undefined.

For year 2 (2001):

X_2 = 498.316

1. Determine the value Smoothing first S_t'

$S_t' = \alpha X_2 + (1-\alpha)S_{t-1}'$

= 0,1(498.316) + (0,9)(388.569)

= 399.543,7

2. Determining the value of Smoothing a second S_t''

$S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}''$

= 0,1(399.543,7) + (0,9)(388.569)

= 389.666,47

3. Determining the value of a constant period *t* (a_t)

$a_t = 2S_t' - S_t''$

= 2(399.543,7)–389.666,47

= 409.421

4. Determine the smoothing constant value (b_t)

$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'')$

$= \frac{0,1}{0,9}$ (399.543,7–389.666,47)

= 1.097,47

Next to find the value of F_{t+m} can not be determined because the values of a_t and b_t has not been determined in the previous year. The value of F_{t+m} can be found in the 3rd year

For the 3rd year (2002)

X_3 = 493.313

1. Determine the value Smoothing first S_t'

$S_t' = \alpha X_3 + (1-\alpha)S_{t-1}'$

= 0,1 (493.313) + (0,9)(399.543,7)

= 408.920,63

2. Determine value Smoothing second S_t''

$S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}''$

= 0,1 (408.920,63) + (0,9)(389.666,47)

= 391.591,88

3. Determining the value of a constant period *t* (a_t)

$a_t = 2S_t' - S_t''$

= 2(408.920,63)–391.591,88

= 426.249,38

4. Determine the smoothing constant value (b_t)

$$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'')$$

$= \frac{0,1}{0,9}(408.920,63–391.591,88)$

$= 1.925,41$

5. Determine the forecast value (F_{t+m}) The 3rd year forecast with m=1

$$F_{2002+1} = a_{2002} + b_{2002}(m)$$

$= = 426.249,38+1.925,41$

$= 428.174,79$

The value of e_t for 2011 are:

$e_{2002} = X_{2002} - F_{2002}$

$=493.313–428.174,79$

$= 65.138,21$

Percentage error 2011 are:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right)100\%$$

$$= \left(\frac{493.313-428.174,79}{493.313}\right)100\%$$

$= 13,20$

Table 3. Double Exponential Smoothing with = 0.1 on the amount of oil palm production in Simalungun Regency**.**

Year	Production Result	S'_t	S''_t	a_t
2000	388.569,00	388.569,00	388.569,00	
2001	498.316,00	399.543,70	389.666,47	409.420,93
2002	493.313,00	408.920,63	391.591,89	426.249,37
2003	494.761,00	417.504,67	394.183,16	440.826,17
2004	494.760,00	425.230,20	397.287,87	453.172,53
2005	502.665,45	432.973,73	400.856,45	465.091,00
2006	505.441,41	440.220,49	404.792,86	475.648,13
2007	490.304,27	445.228,87	408.836,46	481.621,28
2008	493.315,03	450.037,49	412.956,56	487.118,41
2009	111.010,59	416.134,80	413.274,39	418.995,21
2010	507.949,41	425.316,26	414.478,57	436.153,94
2011	508.970,15	433.681,65	416.398,88	450.964,42

2012	513.546,41	441.668,12	418.925,80	464.410,44
2013	522.721,59	449.773,47	422.010,57	477.536,37
2014	114.100,00	416.206,12	421.430,13	410.982,12
2015	43.781,82	378.963,69	417.183,48	340.743,90
2016	517.218,18	392.789,14	414.744,05	370.834,23
2017	547.209,05	408.231,13	414.092,76	402.369,51
2018	122.341,97	379.642,22	410.647,70	348.636,73
2019	512.100,00	392.887,99	408.871,73	376.904,26

b_t	F_{t+m}	e_t	|PE|
1.097,47			
1.925,42	428.174,79	65.138,21	13,20
2.591,28	443.417,45	51.343,55	10,38
3.104,70	456.277,24	38.482,76	7,78
3.568,59	468.659,58	34.005,87	6,77
3.936,40	479.584,53	25.856,88	5,12
4.043,60	485.664,89	4.639,38	0,95
4.120,10	491.238,52	2.076,51	0,42
317,82	419.313,03	-308.302,44	277,72
1.204,19	437.358,13	70.591,28	13,90
1.920,31	452.884,72	56.085,43	11,02
2.526,92	466.937,37	46.609,04	9,08
3.084,77	480.621,14	42.100,45	8,05
-580,44	410.401,68	-296.301,68	259,69
-4.246,64	336.497,26	-292.715,44	668,58
-2.439,43	368.394,80	148.823,38	28,77
-651,29	401.718,22	145.490,83	26,59
-3.445,05	345.191,68	-222.849,71	182,15
-1.775,97	375.128,29	136.971,71	26,75
JUMLAH		**-251.953,97**	**1.556,90**
MAPE		**86,49**	

From table 3 above, the forecast error value can be found using the 13 MAPE equation with the following formula:

$$\text{MAPE} = \sum_{t=1}^{n} \frac{|PE_t|}{n}$$

$$= \frac{1.556,90}{18}$$

$$= 86,49\ \%$$

By using the same calculation, it can be determined the value of Double Exponential Smoothing and the value of future forecasts for $\alpha = 0.2$ to $\alpha = 0.9$.

3.3 Parameters Selection Best

In this study, the best parameter was chosen based on the smallest Mean Absolute Percentage Error (MAPE) value. The predetermined values of are 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. The smallest MAPE calculation results for parameters α = 0.1 to α = 0.9 can be seen in table 4 as follows:

Table 4. MAPE value for the parameter $\alpha = 0.10$ to the $\alpha = 0.90$

Parameter α	Mean Absolute Percentage Error (MAPE)
0,1	86.49 %
0,2	62.31 %
0,3	40.07 %
0,4	22.42 %
0,5	**19.87 %**
0,6	28.18%
0,7	45.30 %
0,8	61.00 %
0,9	73.27 %

It can be seen that the value of the parameter which gives the smallest Mean Absolute Percentage Error (MAPE) value is α = 0.5. Shows the smallest value of parameter at α = 0.5. And to make sure the value of the parameter is relatively the best, the author determines the value of the parameter with 2 numbers behind the decimal, namely 0.51, 0.52, 0.53, 0.54, 0.55, 0.56, 0.57, 0.58, 0.59.

Table 5. MAPE value for the parameter $\alpha = 0.51$ to the $\alpha = 0.59$

Parameter α	Mean Absolute Percentage Error (MAPE)
0,51	**20.28 %**
0,52	20.65 %
0,53	21.18 %
0,54	22.29 %
0,55	23.34 %
0,56	24.34 %
0,57	25.28 %
0,58	26.17 %
0,59	27.01 %

Table 5 shows that the smallest value of the parameter is α = 0.51 with a MAPE value of 20.28%. The best MAPE value that has been obtained by trial and error, then forecasting can then be done using the Double Exponential Smoothing Brown method.

3.4 Forecasting the Amount of Oil Palm Production in Simalungun Regency

So to determine forecasting in the coming year, the formula $F_{t+m} = a_t + b_t(m)$. The values of at and bt are taken from 2019. Because the years to be forecast are 2020, 2021 and 2022, the number of future forecasts is determined by the number of previous years. The following is the

process of completing forecasts for 2020.

a. Forecast for 2020 (m=1)

F_{t+m} = $a_t + b_t$ (m)
F_{2019+1} = $a_{2019} + b_{2019}$ (1)
F_{2020} = 432.823,82+34.471,33
F_{2020} = 467.295,15

b. Forecast for 2021 (m=2)

F_{t+m} = $a_t + b_t$ (m)
F_{2019+2} = $a_{2019} + b_{2019}$ (2)
F_{2021} = 432.823,82+ (34.471,33)(2)
F_{2021} = 501.766,48

c. Forecast for 2021 (m=3)

F_{t+m} = $a_t + b_t$ (m)
F_{2019+3} = $a_{2019} + b_{2019}$ (3)
F_{2021} = 432.823,82+ (34.471,33)(3)
F_{2021} = 536.237,81

Table 6. Forecasting the Amount of Palm Oil Production in Simalungun Regency for 2020, 2021, and 2022.

Year	Period	Forecasting (Palm Production)
2020	21	467.295,15
2021	22	501.766,48
2022	23	536.237,81

From the forecasting results, it can be seen the graph of the Amount of Palm Oil Production in Simalungun Regency from 2000 – 2022 as follows :

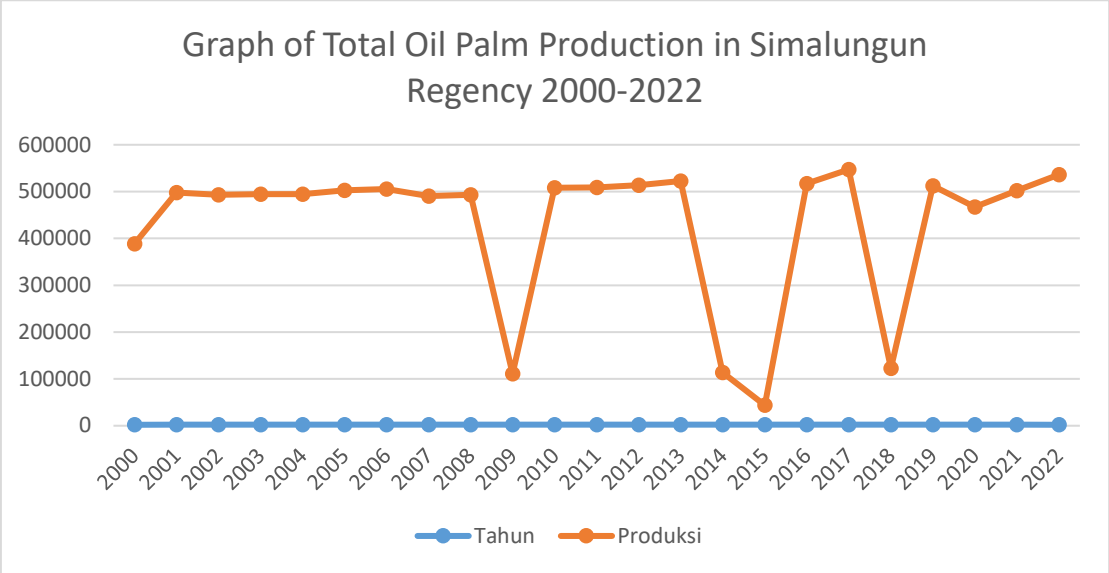

Figure 2. Graph of Total Oil Palm Production in Simalungun Regency 2000-2022

From Figure 2 above, it can be seen that the forecasting of the amount of oil palm production in Simalungun Regency in 2020, 2021 and 2022 has increased every year.

5. Conclusion

Based on the analysis and discussion that has been carried out, it can be concluded that the best parameter obtained for forecasting the amount of oil palm production in Simalungun Regency from 2000 to 2019 is $\alpha = 0.51$ with an error percentage of 20.28% with oil palm production in Simalungun Regency in 2020 is 467,295.15 tons, in 2021 it is 501,766.48 tons, and in 2022 it is 536,237.81 tons.

From this it can be seen that oil palm production in Simalungun Regency increases from year to year, but there are times when it decreases not so drastically, so it can be concluded that oil palm harvest production in Simalungun Regency has increased.

REFERENCES

[1] PS, Tim Penulis. 1997. *Kelapa Sawit, Usaha Budidaya, Pemanfaatan Hasil dan Aspek Pemasaran.* PT Penebar Swadaya. Jakarta

[2] Badan Pusat Statistik (BPS) Sumatera Utara.

[3] Sofyan, Khairani Diana. 2013. *Perencanaan dan Pengendalian Produksi*. Graha Ilmu. Yogyakarta

[4] Assauri, Sofysan. 1984. *Teknik dan Metoda Peramalan*. Jakarta: Fakultas Ekonomi Universitas Indonesia.

[5] Pujiati E, Yuniarti D, Goejantoro R. 2016. *Peramalan Dengan Menggunakan Metode Double Exponential Smoothing dari Brown (Studi Kasus: Indeks Harga Konsumen (IHK) Kota Samarinda).* Jurnal Exponential. Vol. 7(1):33-40.

[6] Makridakis, S, Steven C. Wheelwright, dan Victor E. Mcgee. 2003. *Metode dan Aplikasi Peramalan*, Jakarta: Erlangga.