Journal of Mathematics Technology and Education Vol. 2, No. 2, 2023 | 114 - 125

Journal of Mathematics Technology and Education

Double Exponential Smoothing Method to Forecast the Production of Tembakau in North Sumatra

***TJ Marpaung*[1], *YB Siringoringo*[2], *Rony Genevent Marpaung*[3], *J.L. Marpaung*[4]**

[1,2]*[Programs of Statistics, Faculty of Vocational, Universitas Sumatera Utara]*
[3,4]*[Magister of Mathematics, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara]*

Abstract. Forecasting is the process of using mathematical calculations and quantitative data from the past to predict situations that have not occurred or will occur in the future. Determine the strategy used in pursuing choices based on several things that have been done so that it is very feasible for planning. Brown's Double Exponential Smoothing, especially the smoothing approach with alpha values of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 will be used as a forecasting technique in this study. Using tobacco production data from 2012 to 2021, the forecasting results show that the best guess value achieves the smallest Mean Absolute Precentage Error (MAPE) of the nine alpha values used. with the parameter alpha = 0.2 produces the lowest error rate of 21.37 percent. The form of the forecasting equation is Fi+m = 1666.84892857549 + 86.604473843712 m. That is, the accuracy of forecasting the amount of tobacco production in the next ten years is 65.37 percent.

Keyword: MAPE, Forecasting Method, Tobacco Production

Abstrak. *Peramalan adalah proses menggunakan perhitungan matematis dan data kuantitatif dari masa lalu untuk memprediksi situasi yang belum atau akan terjadi di masa depan. Tentukan strategi yang digunakan dalam mengejar pilihan berdasarkan beberapa hal yang telah dilakukan sehingga layak untuk direncanakan. Brown Double Exponential Smoothing, terutama pendekatan smoothing dengan nilai alpha 0,1, 0,2, 0,3, 0,4, 0,5, 0,6, 0,7, 0,8, dan 0,9 akan digunakan sebagai teknik peramalan dalam penelitian ini. Menggunakan data produksi tembakau dari tahun 2012 hingga 2021, hasil peramalan menunjukkan bahwa nilai tebakan terbaik mencapai Mean Absolute Precentage Error (MAPE) terkecil dari sembilan alpha nil yang digunakan dengan parameter alpha = 0,2, menghasilkan tingkat kesalahan terendah sebesar 21,37 persen. Bentuk persamaan peramalan adalah Fi+m = 1666,84892857549 + 86,604473843712 m. Artinya, akurasi perkiraan jumlah produksi tembakau dalam sepuluh tahun ke depan adalah 65,37 persen.*

Kata Kunci: *MAPE, Metode Peramalan, Produksi Tembakau*

Received 09 December 2022 | Revised 13 December 2022 | Accepted 17 March 2023

*Corresponding author at: Programs of Statistics, Faculty of Vocational, Universitas Sumatera Utara, Medan, Indonesia

E-mail address: tj.marpaung@usu.ac.id

Journal Homepage: https://talenta.usu.ac.id/jomte

1 Introduction

These One commodity that has great potential to improve community welfare is the plantation subsector which has a significant strategic role in improving the national economy by providing sources of income to farmers, creating jobs, and contributing to GDP. The Directorate General of Plantations concentrated its development efforts between 2010 and 2012 on three main commodities: palm oil, rubber, and cocoa. Other leading national plantation products besides the three are cloves, tobacco, tea, sugarcane, and others [1]. The capacity and value of exports of plantation commodities, especially the three main commodities, increased as a result of this program. In addition, tobacco, which is included in the plantation subsector and is also one of the most important national plantation commodities, has contributed in various ways, including by providing high investment value for national economic development, achieving a balance in the national commodity trade balance, employment, and providing a role in increasing state revenue from export duties, excise, and other taxes. Tobacco, as stated by [2-3], is one of the main componentsused in the cigarette industry. Especially thisplant has economic value because tobacco is used as chewing especially for rural women. Maybe nothing happens if tobacco is not grown, but industrial cigarettes are not running, or cigarettes and tobacco are not sold. However, it cannot be ruled out thatits necessary subsystem is absolute. In this case, the development of the plantation industry became a model of modernization in North Sumatra, especially in the city of Medan (Tanah Deli). The first plantation in North Sumatra was a tobacco plantation, and its main product, Deli Tobacco, was internationally renowned. Even according to BPS North Sumatra noted that in 2018-2019 tobacco export results increased by $ 9.85 million or 5.96%, so it can be said that North Sumatra's tobacco export performance is not bad if using the trend benchmark, but the development of tobacco prices in the world market has decreased [4-5]. In general, forecasting is the process of determining the desired level of demand for a product or group of products in a certain period of time in the future by utilizing historical data reference sources. Data from several previous years are used in forecasting methods that will be used in this study to estimate future tobacco production in North Sumatra . While the smoothing technique is used to take the long-term average value to measure its value in the following year. Taking into account the latest fluctuations in data, actions are carried out in forecasting methods that constantly revise estimated values [6].

2 Research Methods

2.1 Data Types and Sources

The study relied on secondary data on annual tobacco production growth from tobacco plantations in each region in North Sumatra over a ten-year period, from 2012 to 2021. BPS Sumut, the Ministry of Agriculture, and the Internet related to the research topic have provided data [7].

2.2 Forecasting Concept

In arranging all that is dubious and challenging to be judged with certainty in making precise and valuable determinations there are two most interesting things to be accomplished, to be more specific, first by providing the right esortion of estimating information that must be important as data and second, which is to keep an eye on remembering the information that has been collected by choosing the right measuring technique. *Time Series* models, econometric models, qualitative forecasting models, and quantitative forecasting models are the four models used to analyze forecasts [8]. One time series model that uses new data for ongoing calculations is *exponential flattening* [9].

2.3 Smoothing with Double Exponential

The exponential smoothing approach has a one-parameter linear model called *Double Exponential Smoothing* that requires forecast results to be smoothed exponentially twice. Due to the fact that both single and double smoothing values with real data in both approaches show components of uptrend and downtrend patterns, Brownian one-parameter linear exponential smoothing method can be compared with linear moving average method. Single exponential smoothing values can be adjusted for trend patterns by adding the difference between double and single exponential smoothing values [10]. The DES Brown method is easier to use because it requires only one parameter and uses small amounts of data.

Here is the formula used to implement Double Exponential Smoothing Brown:

1. Thedouble exponential smoothing can be determined by parameter values between $0< a <1$.
2. The equation calculates a single exponential smoothing value(S_i')

   $S_i' = aX_i + (1 - a)S_{i-1}'$
3. The equation calculates the double exponential smoothing value(S_i'')

   $S_i'' = aS_i' + (1 - a)S_{i-1}''$
4. Set the value of the constant (a_i)

   $a_i = 2 - S_i'S_i''$
5. Setting the trend value (b_i)

$$b_i = \frac{a}{1-a} S_i' - S_i''$$

6. Set forecasting values (F_{i+m})

$F_{i+m} = a\ i + b_i m$

Information

X i : Period value i actual

S_i' : Single exponential smoothing value

S_i'' : Double exponential smoothing value

a_i : Nile ai period smoothing constanti

b_i : Trend or slope value of the data

F_{i+m} : Forecasting result for m of the period to be forecasted

M : Number of future periods to be forecast m = 1,2, 3...x

A : The magnitude of the parameter is smoothed exponentially 0 < a < 1

The value and must be known$S_{i-1}'S_{i-1}''$ to apply the above formula; However, this value is unknown at i = 1. According to [11], the solution for determining the value that must be determined at the beginning of the adperiod is by setting the values of S'1 and S"1 equal to the value of x_1 (actual data). Trial and error is one of the best methods for determining the value of parameter (a), but it is known from the above formula that the Double Exponential Smoothing Brown method uses values between 0 and 1.

2.4 *Mean Absolute Precentage Error* (MAPE)

There is no one optimal method for predicting, which when applied to different situations or data, produces forecasting results quickly and correctly. The best forecasting technique in a time series is the one thatproduces the lowest error value or error value. According to [12], accurate future forecasting is very important. One method for assessing anticipation strategies is the Mean Absolute Precentage Error (MAPE).

One of the time series methodologies used to assess forecast precision is MAPE. This approach is used by calculating the absolute value (F i) of the difference between the actual value (Xi) for the i-th time, expressed as a percentage. The following equation is used to calculate the MAPE value mathematically:

$$\mathrm{MAPE} = \frac{1}{h}\sum_{i-1}^{h}|\mathrm{PE}_i|$$

Information:

h : Many periods

PE_i : Percentage error

$$PE_i = \left(\frac{X_i - F_i}{X_i}\right) \times 100\%$$

Information:

X_i : The i-th period of the actual data value; i = 1,2,3,...x

F_I : The i-th period on the forecasting value; i = 1,2,3,...x

The level of precision of forecasting results can be seen in table 1 after determining the MAPE value:

Table 1. MAPE Precision Value

MAPE Value Precision Precentase	
MAPE value	**Category**
MAPE ≤ 10%	Very Good
10% < MAPE ≤ 20%	Good
20% < MAPE ≤ 50%	Reasonable
MAPE > 50%	Bad

The following equation can be used to determine the degree of forecasting precision after obtaining the MAPE value:

$$\text{Success Percentage} = 100\% - \sum \text{MAPE}$$

Table 2 provides the information necessary to determine whether forecasting is good or bad based on forecasting precision coefficients.

Table 2. Forecasting Precision Level

Precentase Level Precision	
Precision Value	**Category**
> 80%	Very Good
> 60% < 80%	Good
> 40% < 60%	Enough
< 40%	Low

3 Research Results and Discussion

3.1 Data Collection

The Central Bureau of Statistics of North Sumatra Province provides annual tobacco production data in North Sumatra for the last ten years, from 2012 to 2021, which will be used for forecasting. In the forecasting process will be used alpha values 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. Information on tobacco production collected is presented in tabel 3.

Table 3. Shows tobacco production in North Sumatra Province from 2012 to 2020

Year	Total Production (Ton)
2012	496,88
2013	481
2014	1443
2015	601
2016	1475
2017	1184,91
2018	1405,01
2019	1405,01
2020	1737
2021	1751

Source: Central Bureau of Statistics North Sumatra Province

Data Analysis of Double Exponential Smoothing Brown Method The following is a description of the calculation of the Brown Double Exponential Smoothing method in forecasting production results for the next 10 years using an alpha value of 0.2.

Calculate a single exponential smoothing value(S'_i)

$$S'_1 = 496{,}88$$
$$S'_2 = (0{,}2) \times 481 + (1 - 0{,}2) \times 496{,}880 = 493{,}704$$
$$S'_3 = (0{,}2) \times 1443 + (1 - 0{,}2) \times 497{,}704 = 683{,}563$$
$$S'_4 = (0{,}2) \times 601 + (1 - 0{,}2) \times 683{,}563 = 667{,}051$$
$$S'_5 = (0{,}2) \times 1475 + (1 - 0{,}2) \times 667{,}051 = 828{,}640$$
$$S'_6 = (0{,}2) \times 1184{,}91 + (1 - 0{,}2) \times 828{,}64 = 899{,}894$$
$$S'_7 = (0{,}2) \times 1405{,}01 + (1 - 0{,}2) \times 899{,}894 = 1000{,}92$$
$$S'_8 = (0{,}2) \times 1405{,}01 + (1 - 0{,}2) \times 1000{,}92 = 1081{,}74$$
$$S'_9 = (0{,}2) \times 1737 + (1 - 0{,}2) \times 1081{,}74 = 1212{,}79$$
$$S'_{10} = (0{,}2) \times 1751 + (1 - 0{,}2) \times 1212{,}79 = 1320{,}43$$

Calculate double exponential smoothing value(S_i'')

$$S_1'' = 496{,}88$$

$$S_2'' = (0{,}2) \times 493{,}704 + (1 - 0{,}2) \times 496{,}880 = 496{,}245$$

$$S_3'' = (0{,}2) \times 683{,}563 + (1 - 0{,}2) \times 496{,}245 = 533{,}708$$

$$S_4'' = (0{,}2) \times 667{,}051 + (1 - 0{,}2) \times 533{,}708 = 560{,}377$$

$$S_5'' = (0{,}2) \times 828{,}640 + (1 - 0{,}2) \times 560{,}377 = 614{,}030$$

$$S_6'' = (0{,}2) \times 899{,}894 + (1 - 0{,}2) \times 614{,}030 = 671{,}203$$

$$S_7'' = (0{,}2) \times 1000{,}92 + (1 - 0{,}2) \times 671{,}203 = 737{,}146$$

$$S_8'' = (0{,}2) \times 1081{,}74 + (1 - 0{,}2) \times 737{,}146 = 806{,}604$$

$$S_9'' = (0{,}2) \times 1212{,}79 + (1 - 0{,}2) \times 806{,}604 = 887{,}409$$

$$S_{10}'' = (0{,}2) \times 1320{,}43 + (1 - 0{,}2) \times 887{,}409 = 974{,}013$$

Calculating the value of the smoothing constant(a_i)

$$a_1 = 0$$

$$a_2 = 2(493{,}704) - 496{,}245 = 491{,}163$$

$$a_3 = 2(683{,}563) - 533{,}708 = 833{,}418$$

$$a_4 = 2(667{,}051) - 560{,}377 = 773{,}724$$

$$a_5 = 2(828{,}640) - 614{,}030 = 1043{,}251$$

$$a_6 = 2(899{,}894) - 671{,}203 = 1128{,}586$$

$$a_7 = 2(1000{,}92) - 737{,}146 = 1264{,}689$$

$$a_8 = 2(1081{,}74) - 806{,}604 = 1357{,}408$$

$$a_9 = 2(1212{,}79) - 887{,}409 = 1538{,}168$$

$$a_{10} = 2(1320{,}43) - 974{,}013 = 1666{,}848$$

Calculating trend values(b_i)

$$b_1 = 0$$

$$b_2 = \frac{0,2}{(1-0,2)}(409,704 - 496,245) = -0,6352$$

$$b_3 = \frac{0,2}{(1-0,2)}(683,563 - 533,708) = 37,463$$

$$b_4 = \frac{0,2}{(1-0,2)}(667,051 - 560,377) = 26,668$$

$$b_5 = \frac{0,2}{(1-0,2)}(828,640 - 614,030) = 53,652$$

$$b_6 = \frac{0,2}{(1-0,2)}(899,894 - 671,203) = 57,173$$

$$b_7 = \frac{0,2}{(1-0,2)}(1000,92 - 737,146) = 65,943$$

$$b_8 = \frac{0,2}{(1-0,2)}(1081,74 - 806,604) = 68,918$$

$$b_9 = \frac{0,2}{(1-0,2)}(1212,79 - 887,409) = 81,345$$

$$b_{10} = \frac{0,2}{(1-0,2)}(1320,43 - 974,013) = 86,604$$

Calculate forecasting value (Fi+m)

For F 1 (in 2012) = F0+1 = a 0 + b 0 (1) = 0

For F 2 (in 2013) = F1+1 = a 1 + b 1(1) = 496.88 + (0 1) = 496.88 ×

For F 3 (in 2014) = F 2+1 = a 2 + b2(1) = 491.163 + (-0.635 1) = 490.53×

For 4 4 (in 2015) = F 3+1 = a 3 + b3(1) = 833.418 + (37.463 1) = 870.88×

For F 5 (in 2016) = F4+1 = a 4 + b4(1) = 773.724 + (26.668 1) = 800.39 ×

For F 6 (in 2017) = F 5+1 = a 5 + b5(1) = 1043,251 + (53.652 1) = 1096.90×

For F 7 (in 2018) = F6+1 = a 6 + b6(1) = 1128.586 + (57.173 1) = 1185.76×

For F 8 (in 2019) = F7+1 = a 7 + b7(1) = 1264.689 + (65.943 1) = 1330.63×

For F 9 (year 2020) = F8+1 = a 8 + b8(1) = 1357.408 + (68.918 1) = 1426.33×

For F 10 (year 2021) = F9+ 1 = a 9 + b9(1) = 1538.168 + (81.345 1) = 1619.51×

Using the Brown Double Exponential Smoothing method with parameters a = 0.2, the values obtained from forecasting calculations of tobacco production in North Sumatra Province aresummarized in table 4.

Table 4. The forecasting value of total tobacco production in the province North Sumatra

Year	Xi	S'_i	S''_i	ai	bi	F(i+m)
2012	496,88	496,88	496,88			
2013	481	493,70	496,24	491,16	-0,635	496,88
2014	1443	683,56	533,70	833,41	37,46	490,53
2015	601	667,05	560,37	773,72	26,66	870,88
2016	1475	828,64	614,03	1043,25	53,65	800,39
2017	1184,91	899,89	671,20	1128,58	57,17	1096,90
2018	1405,01	1000,92	737,14	1264,68	65,94	1185,76
2019	1405,01	1081,73	806,06	1357,40	68,91	1330,63
2020	1737	1212,78	887,40	1538,16	81,34	1426,33
2021	1751	1320,43	974,01	1666,84	86,60	1619,51

Best A Parameter. The optimal parameter to use in research is the smallest MAPE (Mean Absolute Precentage Error) value. Predefined limit values are 0.1 to 0.9. The smaller the MAPE value obtained, the closer the expected value to the actual value, or the approach used is the best approach (Pujiati et al, 2016). By solving the following equation, the value of MAPE (Mean Absolute Percentage Error) can be calculated.

$$\text{MAPE} = \frac{1}{h} \sum_{i-1}^{h} |PE_i|$$

$$\text{MAPE} = \frac{1}{10} \times 2{,}13670 = 0{,}213670091$$

MAPE = 21.37%

Alpha values at tabel 5 serve as the basis for subsequent MAPE values.

Table 5. MAPE value

Alfa	MAPE
0.1	28,60
0.2	21,37
0.3	21,72
0.4	25,97
0.5	30,61
0.6	35,80
0.7	41,75
0.8	48,72
0.9	57,12

According to tabel 5, it is stated that an alpha value of 0.2 has the lowest error rate. So that predictions can be made for the upcoming period using the alpha calculation result of 0.2. The calculation results for the next 10 periods are as follows.

Fi+m = a i + bim

F10+1 = a 10 + b10(1)

For F 11 (in 2022) F 10+1 = a 10 + b10(1) = 1666.848 + (86.604 1) = 1753.453×

For F 12 (year 2023) F 10+2 = a 10 + b 10(2) = 1666.848 + (86.604 2) = 1840.058×

For F 13 (year 2024) F 10+3 = a 10 + b10(3) = 1666.848 + (86.604 3) = 1926.662 ×

For F 14 (year 2025) F 10+4 = a 10 + b10(4) = 1666.848 + (86.604 4) = 2013.267×

For F 15 (year 2026) F 10+5 = a 10 + b10(5) = 1666.848 + (86.604 5) = × 2099.871

For F 16 (year 2027) F 10+6 = a 10 + b10(6) = 1666.848 + (86.604 6) = 2186.476 ×

For F 17 (year 2028) F 10+7 = a 10 + b10(7) = 1666.848 + (86.604 7) = 2273.08×

For F 18 (year 2029) F 10+8 = a 10 + b10(8) = 1666.848 + (86.604 8) = 2359.685×

For F 19 (year 2030) F 10+9 = a 10 + b10(9) = 1666.848 + (86.604 9) = 2446.289 ×

For F 20 (year 2031) F 10+10 = a 10 + b 10(10) = 1666.848 + (86.604 10) = × 2532.894

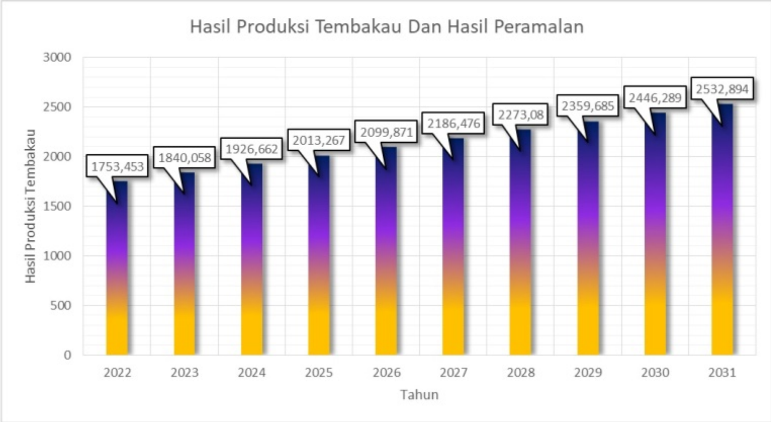

Figure 1. Tobacco Production Results and Forecasting Results

Figure 1 can be seen a graph that illustrates the predicted results of your temba production from 2022 to 2031, there is a tendency for tobacco production to increase. To determine the level of precision of the completed estimate, calculations can be made using the following conditions.

Forecasting Accuracy Rate = 100% - ∑ MAPE

= 100% - 34.63%

= 65.37%

The test results calculated by the Double Exponential Smoothing method showed that out of ten tobacco production data points, the smallest MAPE value was alpha 0.2. This shows that the level of forecasting precision is good, with a figure of 65.37 percent.

4 Conclusion

The result of the MAPE (Mean Absolute Precentage Error) forecasting error at the best alpha value of 0.2 is 21.37%, which means that the error in forecasting is quite good, indicating that the Double Exponential Smoothing method produces a fairly optimal value when predicting tobacco production. North Sumatra Province for the next 10 years using historical data 2012–2021. The results of data processing were obtained, and since the forecasting equation for tobacco products in North Sumatra province is Fi+m = 1666,848+ 86,604(m), it can be said that the province's tobacco production will continue to increase every year. The prediction precision rate for this strategy is 65.37%, indicating satisfactory forecasting results.

References

[1] T. Handayani, R. S. Lubis and R. Aprilia, "Peramalan Tingkat Produksi Kakao Tahun 2021 Di Provinsi Sumatera Utara Dengan Metode Double Eksponential Smoothing Brown," *Mathematics & Application Journal,* vol. IV, pp. 82-91, 2021.

[2] A. I. Sinaga, "Peramalan Banyaknya Pengunjung Perpustakaan di Kota Padangsidimpuan Tahun 2024-2026," 2022. [Online]. Available: https://repositori.usu.ac.id/handle/123456789/53664. [Accessed 4 April 2023].

[3] D. M. Sari, "Peramalan Harga dan Produksi Tembakau di Indonesia," 2008. [Online]. Available: https://repository.ipb.ac.id/handle/123456789/18998. [Accessed 27 Maret 2023].

[4] D. Firmansyah, "Analisis pemasaran tembakau rajangan di Kabupaten Boyolali," 2010. [Online]. Available: https://digilib.uns.ac.id/dokumen/detail/11505/Analisis-pemasaran-tembakau-rajangan-di-Kabupaten-Boyolali. [Accessed 13 April 2023].

[5] M. Rachmat and S. Nuryanti, "Dinamika Agribisinis Tembakau Dunia Dan Implikasinya Bagi Indonesia," *FORUM PENELITIAN AGRO EKONOMI,* vol. XXVII, pp. 73-91, 29 Desember 2009.

[6] N. A. Atussaliha, P. and H. Darwis, "Metode Double Exponential Smoothing pada Sistem Peramalan," *ILKOM Jurnal Ilmiah,* vol. 3, pp. 183-190, Desember 2020.

[7] L. Wulandari, A. Z. Syah and M. A. Sembiring, "Penera[an Metode Double Eksponential Smoothing Untuk Meramalkan Angka Pengangguran," *Jurnal Teknologi Komputer dan Sistem Informasi,* vol. II, pp. 83-87, Agustus 2021.

[8] D. Gartina and R. L. L. Sukriya, STATISTIK PERKEBUNAN INDONESIA 2018-2020, Jakarta: Sekretariat Direktorat Jenderal Perkebunan, 2019.

[9] S. R. Harahap, "Peramalan Jumlah Penduduk Kota Medan pada Tahun 2021 dan 2022 dengan Metode Double Exponential Smoothing Brown," 2021. [Online]. Available: http://repositori.usu.ac.id/handle/123456789/36585. [Accessed 5 April 2023].

[10] Sista, "Aroma Kejayaan Tembakau Deli, Tak Seharum Dulu," 15 July 2019. [Online]. Available: https://kebudayaan.kemdikbud.go.id/aroma-kejayaan-tembakau-deli-tak-seharum-dulu/. [Accessed 17 Maret 2023].

[11] R. Cahyadi, "Tembakau Deli Masih Favorit, Harus Mencari Pasar Baru," 23 Februar1 2020. [Online]. Available: https://medan.tribunnews.com/2020/02/23/tembakau-deli-masih-favorit-harus-mencari-pasar-baru. [Accessed 11 April 2023].

[12] Bakri, "Narasi tentang Sejarah Perkebunan di Sumut," 4 Juli 2019. [Online]. Available: https://aceh.tribunnews.com/2019/07/04/narasi-tentang-sejarah-perkebunan-di-sumut#:~:text=Sejarah%20perkebunan%20di%20Sumut%20dimulai,di%20Hindia%20Belanda%20(Indonesia).. [Accessed 11 April 2023].