CHAPTER 4
ANALYSIS AND DESIGN

4.1. Analysis

In order to achieve the outcomes that were aimed for, data analysis was carried out. In this chapter, we perform an examination of the data that we have obtained in the past using the approach that has been decided upon for making forecasts, which is Holt's method.

The magnitude on the islands of Java, Sumatra, and Bali from 2016 to 2020 was utilized as the data source for the study of the data. The following is a rundown of the information that was obtained::

Table 4.1. *Java Island Data Summary*

Pulau	Tahun	MIN Magnitude	MAX Magnitude	AVERAGE Magnitude	Jumlah Data
JAWA	2016	2,2 SR	5,4 SR	3,58 SR	223 Data
	2017	2,2 SR	5,3 SR	3,57 SR	257 Data
	2018	1,8 SR	4,8 SR	3,42 SR	208 Data
	2019	1,9 SR	5,2 SR	3,40 SR	196 Data
	2020	2,2 SR	6,1 SR	3,54 SR	221 Data
Total Data					1.105 Data

Table 4.2. *Sumatra Island Data Summary*

Pulau	Tahun	MIN Magnitude	MAX Magnitude	AVERAGE Magnitude	Jumlah Data
SUMATERA	2016	2,2 SR	5,7 SR	3,86 SR	218 Data
	2017	2,4 SR	5,3 SR	3,80 SR	257 Data
	2018	2,53 SR	5,2 SR	3,77 SR	210 Data
	2019	2,5 SR	5,5 SR	3,63 SR	234 Data
	2020	2,1 SR	5,3 SR	3,44 SR	294 Data
Total Data					1.213 Data

Table 4.3. *Bali Island Data Summary*

Pulau	Tahun	MIN Magnitude	MAX Magnitude	AVERAGE Magnitude	Jumlah Data
BALI	2016	2,2 SR	4,7 SR	3,20 SR	87 Data
	2017	2,2 SR	5,1 SR	3,28 SR	126 Data
	2018	2,05 SR	5,6 SR	3,29 SR	95 Data
	2019	2,2 SR	4,8 SR	3,25 SR	99 Data
	2020	2,2 SR	5,6 SR	3,39 SR	106 Data
Total Data					513 Data

The annual average magnitude of Java Island, Sumatra Island, and Bali Island indicates that the data is not stationary, as shown in Tables 5.1, 5.2, and 5.3. In addition, the data exhibits an ascending and descending pattern in magnitude. This indicates that the data contains a trend, and can thus be studied using Holt's Double Exponential technique.

4.2. Data Analysis Using Holt. Double Exponential Smoothing (DES) Method

4.2.1. Determining Alpha and Beta Randomly

In the first step, before performing smoothing calculations, we determine alpha and beta randomly from the range 0-1. In this calculation, the alpha and beta used are 0.1, respectively.

4.2.2. Determining Level, Trend, and Forecast Using Holt's DES Method

The magnitude dataset is prepared in weekly form by adding data from Monday to Sunday, then dividing by seven, from the first week of January to the last week of December. Here are the data:

Table 4.4. *Java Island Weekly Data 2016-2018*

Jawa 2016			**Jawa 2017**			**Jawa 2018**	
Periode	**Magnitude**		**Periode**	**Magnitude**		**Periode**	**Magnitude**
1	1,81		1	3,46		1	2,6
2	1,955		2	2,17		2	2,62
3	3		3	1,96		3	2,27
4	1		4	3,14		4	3,6
5	1,96		5	1,11		5	0,8
6	3,31		6	1,69		6	1,49
7	2,95		7	3,38		7	2,91
8	2,7		8	2,7		8	3,08
…….							
47	3,41		53	3,77		53	1,89
48	2,2		54	1,65		54	0,43

49	1,65		55	1,35		55	1,79
50	3,32		56	2		56	2,07
51	1,9		57	2,55		57	2,58
52	1,33		58	2,68		58	1,24
53	3,5		59	2,49		59	1,86

Table 4.5. *Java Island Weekly Data for 2019-2020*

Jawa 2019			**Jawa 2020**	
Periode	**Magnitude**		**Periode**	**Magnitude**
1	0,99		1	2,36
2	0,45		2	3,22
3	2,31		3	2,87
4	0,45		4	1,91
5	0,94		5	1,28
6	1,028		6	1,77
7	2,07		7	2,32
8	2,55		8	1,72
.....				
52	0,97		52	1,42
53	0,94		53	1,45
54	1,98		54	0,55
55	0,96		55	1,86

56	3,41		56	1,59
57	2,04		57	3,29
58	1,45		58	2,07
59	0,95		59	0,4

Table 4.6. *Sumatra Island Weekly Data 2016-2018*

Sumatera 2016			**Sumatera 2017**			**Sumatera 2018**	
Periode	**Magnitude**		**Periode**	**Magnitude**		**Periode**	**Magnitude**
1	1,75		1	3,36		1	2,2
2	2,07		2	2,42		2	3,54
3	3,16		3	2,49		3	3,66
4	1,81		4	2,81		4	2,55
5	2,55		5	1,01		5	1,05
6	3,21		6	2		6	1,42
7	3,18		7	2,94		7	2,53
8	2,63		8	2,51		8	4,06
.....							
51	1,54		51	2,76		51	1,7
52	1,78		52	2,05		52	1,51
53	1,2		53	0,93		53	2,97
54	2,66		54	3,14		54	2,21
55	3,67		55	2,35		55	3,05

56	3,49		56	2,08		56	3,2
57	2,25		57	2,67		57	2,02

Table 4.7. Sumatra Island Weekly Data for 2019-2020

Sumatera 2019			**Sumatera 2020**	
Periode	**Magnitude**		**Periode**	**Magnitude**
1	2,16		1	1,59
2	1,53		2	3,01
3	2,85		3	1,88
4	2,17		4	3,57
5	1,19		5	2,44
6	3,19		6	2,22
7	2,54		7	2,52
8	3,28		8	2,63
.....				
51	1,4		50	3,81
52	1,97		51	0,54
53	2,15		52	1,96
54	2,36		53	3,48
55	2,99		54	3,52
56	2,49		55	3,72
57	0,95		56	0,92

Table 4.8. *Bali Island Weekly Data for* 2016-2018

Bali 2016			**Bali 2017**			**Bali 2018**	
Periode	**Magnitude**		**Periode**	**Magnitude**		**Periode**	**Magnitude**
1	0,4		1	1,55		1	1,03
2	0,4		2	1,3		2	1,94
3	0,87		3	0,51		3	0,45
4	1,85		4	1,12		4	1,14
5	1		5	1,12		5	0,44
6	0,44		6	1,15		6	0,5
7	1		7	0,7		7	0,51
8	0,6		8	1,4		8	1,15
.....							
51	0,8745		52	1,17		53	0,9
52	0,4		53	1,44		54	0,35
53	0,67		54	1,44		55	0,74
54	1,15		55	0,45		56	1,67
55	0,8670		56	0,95		57	1,27
56	0,85		57	0,38		58	1,17

Table 4.9. *Bali Island Weekly Data for 2019-2020*

Bali 2019			**Bali 2020**	
Periode	**Magnitude**		**Periode**	**Magnitude**
1	1,15		1	1
2	0,37		2	2,03
3	1,31		3	1,34
4	0,9433		4	0,32
5	0,95		5	1,17
6	0,74		6	1,97
7	0,84		7	1,38
8	0,87		8	0,78
.....				
50	0,31		52	1,16
51	1,7		53	0,31
52	1,42		54	0,79
53	0,34		55	0,84
54	0,95		56	1,08
55	1,24		57	0,97
56	0,82		58	1,0017

Forecasting using the Holt DES method is carried out using the following three equations:

$$L_t = \alpha X_t + (1 - \alpha)(L_{t-1} + T_{t-1}) \quad (1)$$

$$T_t = \beta(L_t + L_{t-1}) + (1 - \beta)T_{t-1} \quad (2)$$

$$F_{t+m} = L_t + T_t\, m \quad (3)$$

Where,

L_t : *the value of smoothing actual data in periodt*

L_{t-1} : *value of smoothing actual data in period t (t - 1)*

X_t : *actual time series data for periodt*

T_t : *trend smoothing value for periodt*

T_{t-1} : *trend smoothing value for period t (t - 1)*

a, b : *smoothing parameter, 0 < a < 1 and 0 < b < 1*

F_{t+m} : *forecast value for t+m the next period*

m : *future forecast period Forecast*

T1of cannot be established for the island of Java in 2016, as the real value in the first data X1 is based on past actual values. Using the actual value of X2 as the value of L2 and the second actual value minus the first actual value of X2 - X1 as the value of T2, the calculation is continued at L2 and T2:

$L_2 = X_2$

$L_2 = 1{,}955$

$T_2 = X_2 - X_1$

$T_2 = 1{,}955 - 1{,}81$

$T_2 = 0{,}145$

value for the 3rd period can be determined by equation (3), namely:

$F_{t+m} = L_t + T_t m$

$F_{2+1} = L_2 + T_2 * 1$

$F_3 = 1{,}955 + (0{,}145 * 1)$

$F_3 = 2{,}1$

Next to calculate L_3 and T_3, can use equations (1) and (2), so that:

$L_t = \alpha X_t + (1 - \alpha)(L_{t-1} + T_{t-1})$

$L_3 = \alpha X_3 + (1 - \alpha)(L_{3-1} + T_{3-1})$

$L_3 = 0{,}1 * 3 + (1 - 0{,}1)(1{,}955 + 0{,}145)$

$L_3 = 2{,}19$

$T_t = \beta(L_t + L_{t-1}) + (1 - \beta)T_{t-1}$

$T_3 = \beta(L_3 + L_{3-1}) + (1 - \beta)T_{3-1}$

$T_3 = 0{,}1(2{,}19 + 1{,}955) + (1 - 0{,}1) * 0{,}145$

$T_3 = 0{,}154$

The forecast value for the 4th period can be determined by equation (3), namely:

$F_{t+m} = L_t + T_t m$

$F_{3+1} = L_3 + T_3 * 1$

$F_4 = 2{,}19 + (0{,}154 * 1)$

$F_4 = 2{,}344$

Next, do the calculations for L_5 and T_5 and F_{5+1} to the 53rd data to produce a value of F_{53+1}. Then the calculation table is obtained:

Table 4.10. *Calculation of DES Holt Java Island in 2016*

Periode	Magnitude	L_t	T_t	Forecast
1	1,81	-	-	-
2	1,955	1,955	0,145	-
3	3	2,19	0,154	2,1
4	1	2,2096	0,141	2,344
5	1,96	2,31	0,137	2,3502
6	3,31	2,53	0,145	2,4478
7	2,95	2,71	0,148	2,6793
8	2,7	2,84	0,146	2,8544
9	2,5	2,94	0,142	2,9854
10	3,56	3,13	0,146	3,0784
.....				
49	1,65	2,4447	0,02	2,533
50	3,32	2,55	0,028	2,4644
51	1,9	2,5104	0,021	2,5782
52	1,33	2,4116	0,009	2,5318
53	3,5	2,529	0,02	2,4211
54	-	-	-	2,5492

The 54th phase is the implementation of m = 1, the expected value of January's magnitude in the first week of 2017. To determine the following period, use m = 2 for the 55th period of January, the second week. 2017; m = 3 for the 56th period of January, the third week of 2017; m = 4 for the 57th period of January, the fourth week of 2017; and m = 5 for the 58th period of January, the fifth week, calculated using equation (3), with the values Lt last L53 and Tt last T53.:

55th period, with m = 2

$F_{t+m} = L_t + T_t m$

$F_{53+2} = L_{53} + T_{53} * 2$

$F_{55} = 2{,}529 + (0{,}02*2)$

$F_{55} = 2{,}5694$

56th period, with m = 3

$F_{t+m} = L_t + T_t m$

$F_{53+3} = L_{53} + T_{53} * 3$

$F_{56} = 2{,}529 + (0{,}02*3)$

$F_{56} = 2{,}5896$

57th period, with m = 4

$F_{t+m} = L_t + T_t m$

$F_{53+4} = L_{53} + T_{53} * 4$

$F_{57} = 2{,}529 + (0{,}02*4)$

$F_{57} = 2{,}5896$

58th period, with m = 5

$F_{t+m} = L_t + T_t m$

$F_{53+5} = L_{53} + T_{53} * 5$

$F_{58} = 2{,}529 + (0{,}02*5)$

F_{58} = 2,63

4.2.3. Measuring Prediction Error by Calculating MAPE

After establishing a model through forecasting, it is required to assess the model's correctness. The result obtained from a measurement device for forecasting mistakes indicates the error rate of the model being evaluated, therefore the lower the value obtained, the greater the level of accuracy. MAPE is one of the instruments used to measure the error rate of a forecasting model (Mean Absolute Percentage Error). To compute MAPE, the formula is:

$$MAPE = \frac{\sum_{t=1}^{n} \left| \frac{X_t - F_t}{X_t} \times 100\% \right|}{n} \quad (4)$$

Where,

X_t : *actual time series data for period t*

F_t : *forecast value for period t*

n : *total number of data*

Table 4.11. *MAPE Value Range*

Range MAPE	**Arti Nilai**
< 10%	The ability of the forecasting model is very good
10 - 20%	The ability of the forecasting model is good
20 - 50%	The ability of the forecasting model is decent
> 50%	The ability of the forecasting model is bad

The following is a table for calculating the error rate of the forecasting model by measuring the difference F_t with actual data:

Table 4.12. *2016 Modeling Error Rate*

Periode	Magnitude	Forecast	error
1	1,81	-	-
2	1,955	-	-
3	3	2,1	0,9
4	1	2,344	-1,344
5	1,96	2,3502	-0,3902
6	3,31	2,4478	0,8622
7	2,95	2,6793	0,2707
8	2,7	2,8544	-0,1544
9	2,5	2,9854	-0,4854
10	3,56	3,0784	0,4816
.....			
49	1,65	2,533	-0,883
50	3,32	2,4644	0,8556
51	1,9	2,5782	-0,6782
52	1,33	2,5318	-1,2018
53	3,5	2,4211	1,0789

MAPE can be used to measure the error rate of the forecasting model if the size of the error rate for each modeling period is known. The calculation of the forecasting error rate begins with the error rate in the third period and continues until the final period because the error rate in the first and second periods used to determine the starting smoothing value is 0. According to equation (4), the MAPE value for alpha = 0.1 and beta = 0.1 was 94.98 %.

4.2.4. Determination of the Best Alpha and Beta Based on the Smallest MAPE

If the MAPE value has been got, then the alpha and beta values can be changed until the MAPE value changes to the smallest value. The goal is that the prediction results can approach the actual data.

Table 4.13. MAPE values based on Alpha and Beta

No	Alpha	Beta	MAPE
1	0,1	0,1	94,98%
2	0,5	0,2	45,64%
3	1	0,04	36,04%

Alpha 1 and beta values of 0.04 are got through a looping process in the python program to produce the smallest MAPE value of 36,04%

If the forecast calculation is continued by updating the dataset in the 54th Period onwards, then you can continue the calculation to equations (1), and (2) to get the forecast value for the next 6 months:

Table 4.14. *Calculation of DES Holt Java Island January 2017 – June 2017*

Periode	Magnitude	L_t	T_t	Forecast
1	3.46	3.46	0.06442	3.56877
2	2.17	2.17	0.01024	3.52442
3	1.96	1.96	0.00143	2.18024
4	3.14	3.14	0.04857	1.96143
5	1.11	1.11	-0.0346	3.18857
6	1.69	1.69	-0.01	1.07543
7	3.38	3.38	0.05801	1.68001
8	2.7	2.7	0.02849	3.43801

9	2.74	2.74	0.02895	2.72849
10	1.14	1.14	-0.0362	2.76895
.....				
25	0.47	0.47	-0.0719	3.06178
26	1.45	1.45	-0.0298	0.39811
27	1.97	1.97	-0.0078	1.42019
28	2	2	-0.0063	1.96218
29	0.57	0.57	-0.0633	1.99369
30	1.51	1.51	-0.0231	0.50674

The 30th period is the data value for June 2017, the last week, Then the error value and error percentage are determined to get the MAPE value:

Table 4.15. *Error Rate (Error) Modeling January 2017 – June 2017*

Periode	Magnitude	Forecast	error
1	3.46	-0.1088	0.03144
2	2.17	-1.3544	0.62416
3	1.96	-0.2202	0.11237
4	3.14	1.17857	0.37534
5	1.11	-2.0786	1.87259
6	1.69	0.61457	0.36365
7	3.38	1.69999	0.50295
8	2.7	-0.738	0.27334
9	2.74	0.01151	0.0042
10	1.14	-1.629	1.42891
.....			
26	1.45	1.05189	0.72544
27	1.97	0.54981	0.27909
28	2	0.03782	0.01891

29	0.57	-1.4237	2.4977
30	1.51	1.00326	0.66441

68,62 % is the value from January 2017 to June 2017 with alpha 1 and beta 0.04. This indicates a rise in MAPE from the prior year, with the best alpha and beta reference from the prior year from 36,04% to 68,62%.

4.3. Design

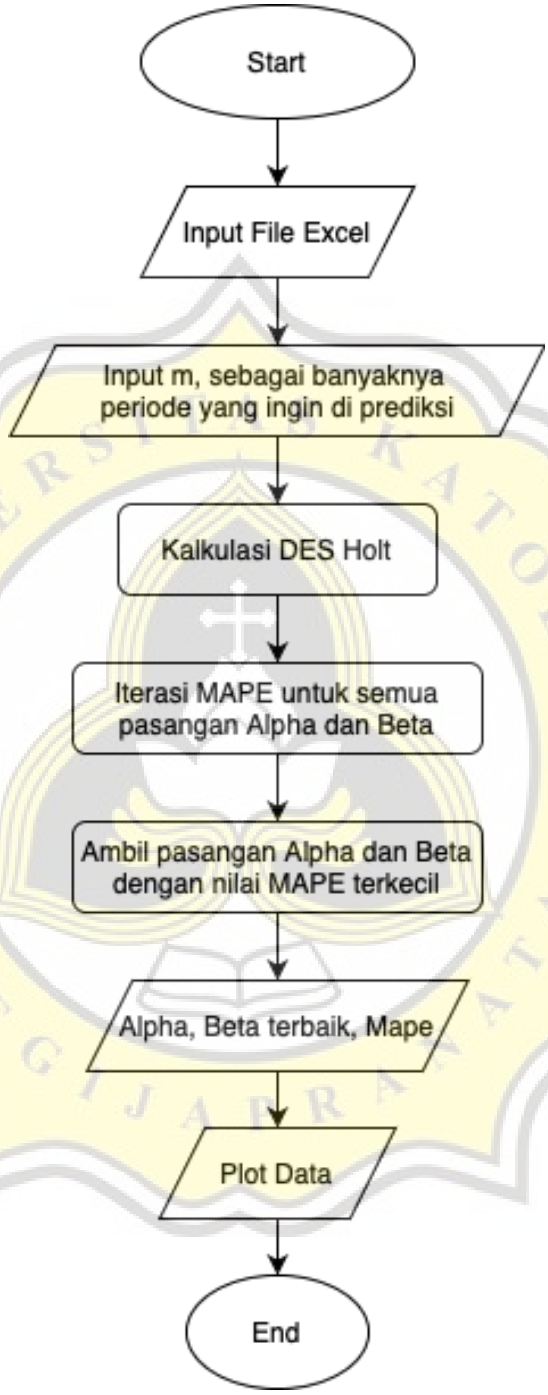

Figure 4.1 *Flowchart Program DES Holt*