

CHAPTER 5

IMPLEMENTATION AND RESULTS

5.1. Implementation

5.1.1. Double Exponential Smoothing Holt Algorithm

```
1. def double_exponential_smoothing(y, alpha, beta, n_preds=k):
2.     n_record = y.shape[0]
3.     results = np.zeros(n_record + n_preds)
4.
5.     levels = [0.0, y[1]]
6.     trends = [0.0, y[1] - y[0]]
7.     forecasts = [0.0, 0.0]
8.
9.     for t in range(2, n_record):
10.        value = y[t]
11.
12.        level = (alpha * value) + ((1 - alpha) * (levels[t-
13.        1] + trends[t-1]))
14.        levels.append(level)
15.
16.        trend = (beta * (levels[t] - levels[t-1])) + ((1 -
17.        beta) * trends[t-1])
18.        trends.append(trend)
19.
20.        result = levels[t-1] + trends[t-1]
21.        forecasts.append(result)
22.
23.    if n_preds > 1:
24.        forecasts[n_record+1 :] = levels[-1] +
25.        (np.arange(1, n_preds + 1) * trends[-1])
26.
27.    return forecasts
```

Line 5, 6, 7 for manual value input, according to the formula because in the first data Level, Trend, and Forecast the value is 0, then in the second line the Level

value is the same as the second Magnitude value, the second Trend value is the second Magnitude value minus the first Magnitude value, and the second forecast value is 0. Then in line 9 the DES calculation for the third value is carried out in a loop until the last data is according to equations (1) and (2) to calculate the Level, Trend, and Forecast described in line 12, 15, and 19. In line 21 explains that `n_preds` is `k` (i.e. the number of periods to be predicted). The formula to determine forecast based on `k` according to equation (3).

5.1.2. Finding Best Alpha, Best Beta, and Best MAPE

```
1. best_mape = np.inf
2. best_config_mape = []
3.
4. n_preds = k
5.
6. for alpha in np.arange(0.00, 1.02, 0.02):
7.     for beta in np.arange(0.00, 1.02, 0.02):
8.         levels = [0.0, y[1]]
9.         trends = [0.0, y[1] - y[0]]
10.        forecasts = [0.0, 0.0,]
11.
12.        n_record = y.shape[0]
13.        results = np.zeros(n_record + n_preds)
14.
15.        for t in range(2, n_record):
16.            value = y[t]
17.
18.            level = (alpha * value) + ((1 - alpha) *
19.                (levels[t-1] + trends[t-1]))
20.
21.            levels.append(level)
22.
23.            trend = (beta * (levels[t] - levels[t-1])) +
24.                ((1 - beta) * trends[t-1])
25.            trends.append(trend)
26.
27.            result = levels[t-1] + trends[t-1]
28.            forecasts.append(result)
```

```

26.
27.         if n_preds > 1:
28.             forecasts[n_record + 1:] = levels[-1] +
(np.arange(1, n_preds + 1) * trends[-1])
29.
30.         mape =
mean_absolute_percentage_error(y[2:n_record+1],
forecasts[2:n_record])*100
31.
32.         cfgm = [alpha, beta, mape]
33.
34.         if mape < best_mape:
35.             best_mape = mape
36.             cfg_mape = [alpha, beta, best_mape]
37.             best_config_mape = cfg_mape
38.     print('Best alpha, beta and MAPE are : ', best_config_mape)

```

Line 6 and Line 7 explain that the program runs a loop command for iterating alpha and beta values from a range of 0 to 1 with a range of 0.02 when performing Holt DES calculations to find Level, Trend, and Forecast. On Line 30 is the mean_absolute_percentage_error library from skicit. Line 34 explains that if the mape value has been got which is the smallest from best_mape, then the best_mape value is mape, then cfg_mape which contains alpha, beta, and best_mape values is entered the best_config_mape command. On Line 38 print the best alpha, the best beta, and best mape results.

5.2. Results

5.2.1. Holts Double Exponential Smoothing Calculation Results

following table shows the results of further Double Exponential Smoothing Holts calculation for Java Island, Sumatra Island, and Bali Island:

Table 5.1. Calculation of DES Holt in Java in 2017-2018

Perhitungan DES Jawa 2017					Perhitungan DES Jawa 2018				
Periode	Magnitude	L_t	T_t	Forecast	Periode	Magnitude	L_t	T_t	Forecast
1	3,46	-	-	-	1	2,6	-	-	-
2	2,17	2,17	-1,29	-	2	2,62	2,62	0,02	-
3	1,96	0,98	-1,27	0,88	3	2,27	2,60	0,016	2,64
4	3,14	0,05	-1,24	-0,291	4	3,6	2,71	0,026	2,619
5	1,11	-0,96	-1,22	-1,193	5	0,8	2,549	0,006	2,743
			
56	2	2,81	0,031	2,906	56	2,07	1,4733	-0,02	1,407
57	2,55	2,81	0,028	2,846	57	2,58	1,5633	-0,01	1,450
58	2,68	2,82	0,026	2,844	58	1,24	1,5205	- 0,014	1,5518
59	2,49	2,818	0,023	2,854	59	1,86	1,54127	- 0,011	1,5059
60	-	-	-	2,841	60	-	-	-	1,5301

Table 5.2. Calculation of DES Holt in Java for 2019-2020

Perhitungan DES Jawa 2019					Perhitungan DES Jawa 2020				
Periode	Magnitude	L_t	T_t	Forecast	Periode	Magnitude	L_t	T_t	Forecast
1	0,99	-	-	-	1	2,36	-	-	-
2	0,45	0,45	-0,54	-	2	3,22	3,22	0,86	-
3	2,31	0,15	-0,51	-0,09	3	2,87	3,959	0,847	4,08
4	0,45	-0,28	-0,50	-0,366	4	1,91	4,517	0,818	4,806
5	0,94	-0,61	-0,49	-0,792	5	1,28	4,930	0,778	5,336
.....								
56	3,41	1,85	-0,003	1,677	56	1,59	1,302	-0,031	1,270
57	2,04	1,86	-0,001	1,847	57	3,29	1,473	-0,010	1,271
58	1,45	1,82	-0,005	1,865	58	2,07	1,523	-0,004	1,462
59	0,95	1,731	-0,014	1,818	59	0,4	1,406	-0,016	1,518
60	-	-	-	1,717	60	-	-	-	1,390

Table 5.3. Calculation of DES Holt Sumatra Island 2016-2017

Perhitungan DES Sumatera 2016					Perhitungan DES Sumatera 2017				
Periode	Magnitud e	L_t	T_t	Forecas t	Period e	Magnitud e	L_t	T_t	Forecas t
1	1,75	-	-	-	1	3,36	-	-	-
2	2,07	2,07	0,32	-	2	2,42	2,42	-0,94	-
3	3,16	2,467	0,327	2,39	3	2,49	1,581	-0,929	1,48
4	1,81	2,696	0,317	2,7947	4	2,81	0,867	-0,908	0,6511

5	2,55	2,967	0,313	3,0141	5	1,01	0,063	-0,897	-0,0413
			
54	2,66	1,693	-0,020	1,5861	54	3,14	2,804	0,012	2,7674
55	3,67	1,873	-0,000	1,6733	55	2,35	2,770	0,008	2,8173
56	3,49	2,034	0,016	1,8728	56	2,08	2,708	0,001	2,7785
57	2,25	2,070	0,018	2,0506	57	2,67	2,705	0,006	2,7097
58	-	-	-	2,0885	58	-	-	-	2,7063

Table 5.4. Calculation of DES Holt, Sumatra Island in 2018-2019

Perhitungan DES Sumatera 2018					Perhitungan DES Sumatera 2019				
Periode	Magnitude	L_t	T_t	Forecast	Periode	Magnitude	L_t	T_t	Forecast
1	2,2	-	-	-	1	2,16	-	-	-
2	3,54	3,54	1,34	-	2	1,53	1,53	-0,63	-
3	3,66	4,758	1,327	4,88	3	2,85	1,095	-0,611	0,9
4	2,55	5,732	1,292	6,085	4	2,17	0,653	-0,593	0,485
5	1,05	6,427	1,232	7,024	5	1,19	0,172	-0,582	0,059
			
54	2,21	0,502	-0,08	0,312	54	2,36	2,260	0,008	2,249
55	3,05	0,683	-0,05	0,421	55	2,99	2,341	0,015	2,269
56	3,2	0,886	-0,02	0,628	56	2,49	2,370	0,017	2,357
57	2,02	0,973	-0,01	0,856	57	0,95	2,2440	0,0029	2,387
58	-	-	-	0,955	58	-	-	-	2,246

Table 5.5. Calculation of DES Holt, Sumatra Island in 2020

Perhitungan DES Sumatera 2020				
Periode	Magnitude	L_t	T_t	Forecast
1	1,59	-	--	-
2	3,01	3,01	1,42	-
3	1,88	4,1750	1,3945	4,43
4	3,57	5,3696	1,3745	5,5695
5	2,44	6,3136	1,3315	6,7441
.....				
53	3,48	1,6422	-0,0668	1,4380
54	3,52	1,7699	-0,0473	1,5754
55	3,72	1,9223	-0,0273	1,7226
56	0,92	1,7975	-0,0371	1,8950
57	-	-	-	1,7604

Table 5.6. Calculation of DES Holt Bali Island 2016-2017

Perhitungan DES Bali 2016					Perhitungan DES Bali 2017				
Periode	Magnitude	L_t	T_t	Forecast	Periode	Magnitude	L_t	T_t	Forecast
1	0,4	-	-	-	1	1,55		--	-
2	0,4	0,4	0	-	2	1,3	1,3	-0,25	-
3	0,87	0,447	0,005	0,4	3	0,51	0,996	-0,255	1,05
4	1,85	0,591	0,019	0,451	4	1,12	0,778	-0,251	0,740
5	1	0,649	0,022	0,610	5	1,12	0,586	-0,24	0,526

			
53	0,67	0,733	-0,009	0,740	54	1,44	1,627	0,026	1,647
54	1,15	0,766	-0,005	0,724	55	0,45	1,532	0,014	1,653
55	0,8670	0,771	-0,004	0,761	56	0,95	1,487	0,008	1,546
56	0,85	0,775	-0,003	0,767	57	0,38	1,383	-0,003	1,495
57	-	-	-	0,772	58		--	-	1,380

Table 5.7. Calculation of the Bali Island Holt DES 2018-2019

Perhitungan DES Bali 2018					Perhitungan DES Bali 2019				
Periode	Magnitude	L_t	T_t	Forecast	Periode	Magnitude	L_t	T_t	Forecast
1	1,03	-	-	-	1	1,15	-	-	-
2	1,94	1,94	0,91	-	2	0,37	0,37	-0,78	-
3	0,45	2,610	0,886	2,85	3	1,31	-0,24	-0,76	-0,41
4	1,14	3,260	0,862	3,4960	4	0,943	-0,806	-0,743	-1,001
5	0,44	3,754	0,825	4,1228	5	0,95	-1,299	-0,718	-1,5497
			
55	0,74	0,468	-0,018	0,4386	53	0,34	1,444	0,025	1,5672
56	1,67	0,572	-0,006	0,4501	54	0,95	1,417	0,019	1,4696
57	1,27	0,636	0,0006	0,5657	55	1,24	1,417	0,017	1,4375
58	1,17	0,690	0,0059	0,6367	56	0,82	1,3741	0,0117	1,4356
57	-	-	-	0,6960	57	-	-	-	1,3858

Table 5.8. Calculation of DES Holt, Bali Island in 2020

Perhitungan DES Bali 2020				
Periode	Magnitude	L_t	T_t	Forecast
1	1	-	-	-
2	2,03	2,03	1,03	-
3	1,34	2,89	1,01	3,06
4	0,32	3,543	0,977	3,901
5	1,17	4,1847	0,9435	4,5197
.....				
55	0,84	-0,0579	-0,0484	-0,1577
56	1,08	0,0123	-0,0366	-0,1064
57	0,97	0,0751	-0,0266	-0,0243
58	1,0017	0,1438	-0,0171	0,0485
59	-	-	-	0,1268

5.2.2. Prediction Error Rate Calculation Results

The results of the advanced forecast error rate calculations for Java, Sumatra, and Bali are presented in the table below:

Table 5.9. Java Island Modeling Error Rate 2017-2018

Jawa 2017				Jawa 2018			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	3,46	-	-	1	2,6	-	-
2	2,17	-	-	2	2,62	-	-
3	1,96	0,88	1,08	3	2,27	2,64	-0,37
4	3,14	-0,291	3,4312	4	3,6	2,6193	0,9807

5	1,11	-1,193	2,3030	5	0,8	2,7435	-1,943
.....						
49	1,35	3,0341	-1,684	55	1,79	1,3973	0,3927
50	2	2,906	-0,905	56	2,07	1,4071	0,6629
51	2,55	2,846	-0,296	57	2,58	1,4504	1,1296
52	2,68	2,844	-0,164	58	1,24	1,5518	-0,311
53	2,49	2,854	-0,364	59	1,86	1,5059	0,3541

Table 5.10. Java Island Modeling Error Rate 2019-2020

Jawa 2019				Jawa 2020			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	0,99	-	-	1	2,36	-	-
2	0,45	-	-	2	3,22	-	-
3	2,31	-0,09	2,4	3	2,87	4,08	-1,21
4	0,45	-0,3660	0,8160	4	1,91	4,8069	-2,896
5	0,94	-0,7922	1,7322	5	1,28	5,3361	-4,056
.....						
55	0,96	1,7794	-0,819	55	1,86	1,2432	0,6168
56	3,41	1,6771	1,7329	56	1,59	1,2706	0,3194
57	2,04	1,8472	0,1928	57	3,29	1,2714	2,0186
58	1,45	1,8653	-0,415	58	2,07	1,4623	0,6077
59	0,95	1,8185	-0,868	59	0,4	1,5182	-1,118

Table 5.11. Sumatra Island Modeling Error Rate 2016-2017

Sumatera 2016				Sumatera 2017			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	1,75	-	-	1	3,36	-	-
2	2,07	-	-	2	2,42	-	-
3	3,16	2,39	0,77	3	2,49	1,48	1,01
4	1,81	2,7947	-0,984	4	2,81	0,6511	2,1589

5	2,55	3,0141	-0,464	5	1,01	-0,0413	1,0513
		
53	1,2	1,6633	-0,463	53	0,93	2,9616	-2,031
54	2,66	1,5861	1,073	54	3,14	2,7674	0,3726
55	3,67	1,6733	1,9967	55	2,35	2,8173	-0,467
56	3,49	1,8728	1,617	56	2,08	2,7785	-0,698
57	2,25	2,0506	0,1994	57	2,67	2,7097	-0,039

Table 5.12. Sumatra Island Modeling Error Rate 2018-2019

Sumatera 2018				Sumatera 2019			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	2,2	-	-	1	2,16	-	-
2	3,54	-	-	2	1,53	-	-
3	3,66	4,88	-1,22	3	2,85	0,9	1,95
4	2,55	6,0858	-3,535	4	2,17	0,485	1,686
5	1,05	7,0247	-5,974	5	1,19	0,0594	1,1306
		
53	2,97	0,1286	2,841	53	2,15	2,2521	-0,102
54	2,21	0,3125	1,897	54	2,36	2,2495	0,1105
55	3,05	0,4210	2,629	55	2,99	2,2693	0,7207
56	3,2	0,6289	2,571	56	2,49	2,3573	0,1327
57	2,02	0,8567	1,1633	57	0,95	2,3878	-1,437

Table 5.13. Sumatra Island Modeling Error Rate, 2020

Sumatera 2020			
Periode	Magnitude	Forecast	Error
1	1,59	-	-
2	3,01	-	-
3	1,88	4,43	-2,55
4	3,57	5,5695	-2,000
5	2,44	6,7441	-4,3041
.....			
52	1,96	1,4769	0,4831
53	3,48	1,4380	2,0420
54	3,52	1,5754	1,9446
55	3,72	1,7226	1,9974
56	0,92	1,8950	-0,9750

Table 5.14. Bali Island Modeling Error Rate 2016-2017

Bali 2016				Bali 2017			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	0,4	-	-	1	1,55	-	-
2	0,4	-	-	2	1,3	-	-
3	0,87	0,4	0,47	3	0,51	1,05	-0,54
4	1,85	0,4517	1,3983	4	1,12	0,7406	0,3794
5	1	0,6102	0,3898	5	1,12	0,5269	0,5931
.....						
52	0,4	0,7884	-0,388	53	1,44	1,6396	-0,199
53	0,67	0,7407	-0,070	54	1,44	1,6477	-0,207
54	1,15	0,7240	0,426	55	0,45	1,6530	-1,203
55	0,8670	0,7612	0,105	56	0,95	1,5467	-0,596
56	0,85	0,7675	0,082	57	0,38	1,4951	-1,115

Table 5.15. Bali Island Modeling Error Rate 2018-2019

Bali 2018				Bali 2019			
Periode	Magnitude	Forecast	Error	Periode	Magnitude	Forecast	Error
1	1,03	-	-	1	1,15	-	-
2	1,94	-	-	2	0,37	-	-
3	0,45	2,85	-2,4	3	1,31	-0,41	1,72
4	1,14	3,4960	-2,356	4	0,943	-1,001	1,944
5	0,44	4,1228	-3,682	5	0,95	-1,5497	2,4997
		
54	0,35	0,4726	-0,122	52	1,42	1,5421	-0,122
55	0,74	0,4386	0,3014	53	0,34	1,5672	-1,227
56	1,67	0,4501	1,2199	54	0,95	1,4696	-0,519
57	1,27	0,5657	0,7043	55	1,24	1,4375	-0,197
58	1,17	0,6367	0,5333	56	0,82	1,4356	-0,615

Table 5.16. Bali Island Modeling Error Rate, 2020

Bali 2020			
Periode	Magnitude	Forecast	Error
1	1	-	-
2	2,03	-	-
3	1,34	3,06	-1,72
4	0,32	3,901	-3,581
5	1,17	4,5197	-3,3497
		
54	0,79	-0,1981	0,9881
55	0,84	-0,1577	0,9977
56	1,08	-0,1064	1,1864
57	0,97	-0,0243	0,9943
58	1,0017	0,0485	0,9532

5.2.3. MAPE (Mean Absolute Percentage Error) Calculation Results

The results of computing the advanced prediction error rate for Java, Sumatra, and Bali are presented in the table below:

Table 5.17. MAPE Value based on Alpha and Beta of Java Island in 2017-2018

NO	Jawa 2017			Jawa 2018		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	154,29%	0,1	0,1	142,22%
2	0,5	0,2	63,2%	0,5	0,2	132,82%
3	0,68	0,04	59,88%	1	0,14	86,19%

Table 5.18. MAPE Value based on Alpha and Beta of Java Island in 2019-2020

NO	Jawa 2019			Jawa 2020		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	108,87%	0,1	0,1	160%
2	0,5	0,2	69,11	0,5	0,2	70,07%
3	0,38	0,04	56,85%	0,26	0,54	68,1%

Table 5.19. MAPE Value based on Alpha and Beta of Sumatra Island in 2016-2018

NO	Sumatera 2016			Sumatera 2017			Sumatera 2018		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	81,67%	0,1	0,1	105,29%	0,1	0,1	184,5%
2	0,5	0,2	60,14%	0,5	0,2	48,56%	0,5	0,2	66,2%
3	0,12	1	55,92%	0,46	0,06	46,97%	0,9	0,18	56,76%

Table 5.20. MAPE Value based on Alpha and Beta of Sumatra Island in 2019-2020

NO	Sumatera 2019			Sumatera 2020		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	94,32%	0,1	0,1	185%
2	0,5	0,2	68%	0,5	0,2	57,44%
3	0,54	0,02	57,14%	0,82	0,26	56,2%

Table 5.21. MAPE value based on the Alpha and Beta of the island of Bali in 2016-2018

NO	Bali 2016			Bali 2017			Bali 2018		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	48,5%	0,1	0,1	86,6 %	0,1	0,1	304%
2	0,5	0,2	50,23%	0,5	0,2	70,84%	0,5	0,2	79,86%
3	0,02	0	39,86%	0,48	0	58,37%	0,8	0,32	74,17%

Table 5.22. MAPE values based on the Alpha and Beta of the island of Bali in 2019-2020

NO	Bali 2019			Bali 2020		
	Alpha	Beta	MAPE	Alpha	Beta	MAPE
1	0,1	0,1	275%	0,1	0,1	294,81%
2	0,5	0,2	45,64%	0,5	0,2	70,8%
3	0,54	0,18	60,72%	0,34	0,52	65,76%

Table 5.23. Average MAPE Value 2016-2020

PULAU	AVERAGE MAPE 2016-2020
JAWA	67,93%
SUMATERA	54,6%
BALI	59,77%

5.2.4. 5.2.4. Holt. DES Calculation Data Plot

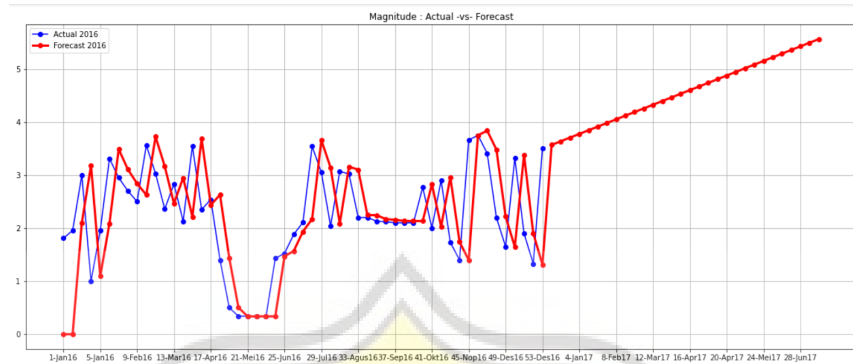


Figure 5.1 Graph of Actual and Predicted Value of Java Island in 2016

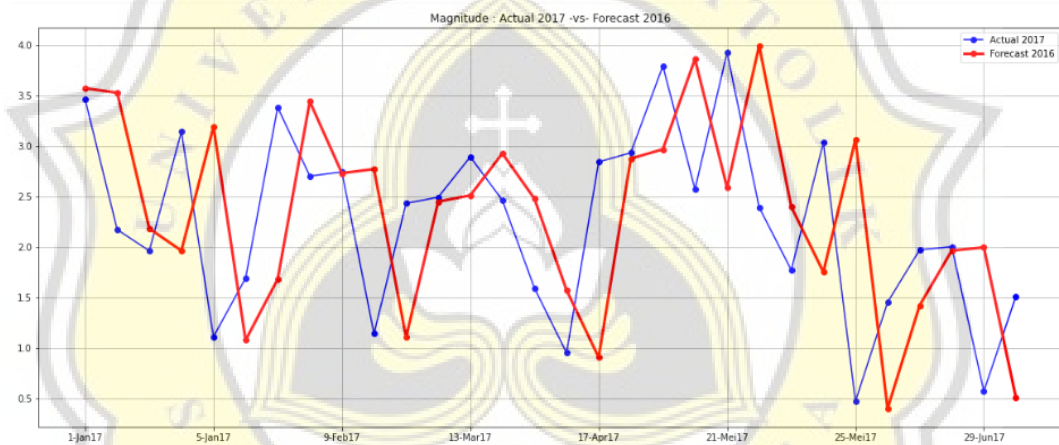


Figure 5.2 Comparison Graph of Java Island Prediction Results in 2016 and Actual Value in 2017

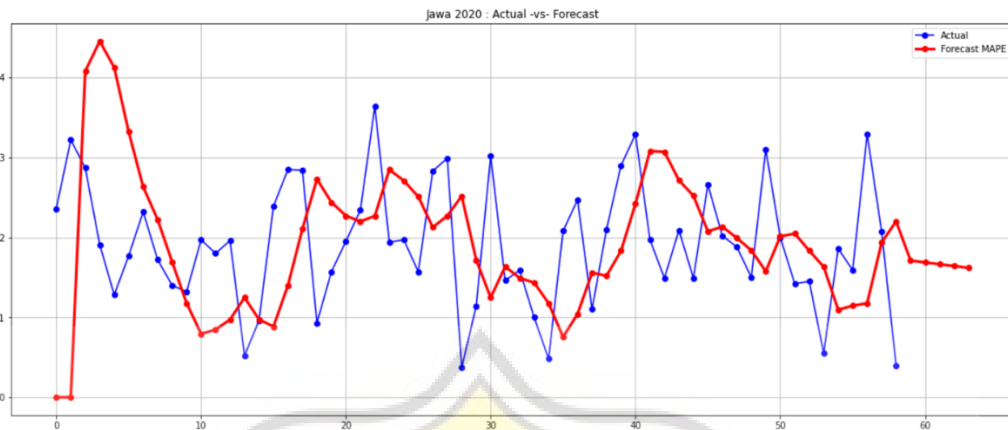


Figure 5.3 Graph of the Actual and Predicted Value of Java Island in 2020

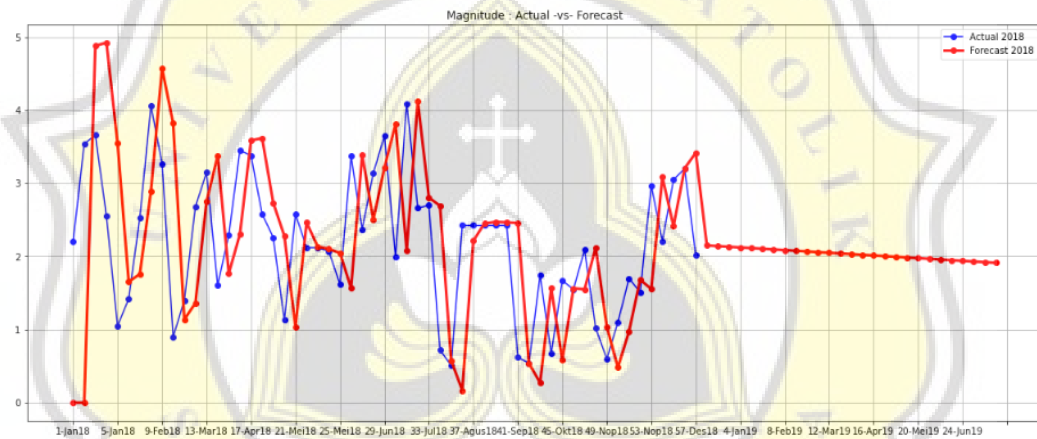


Figure 5.4 Graph of Actual and Predicted Value of Sumatra Island in 2018

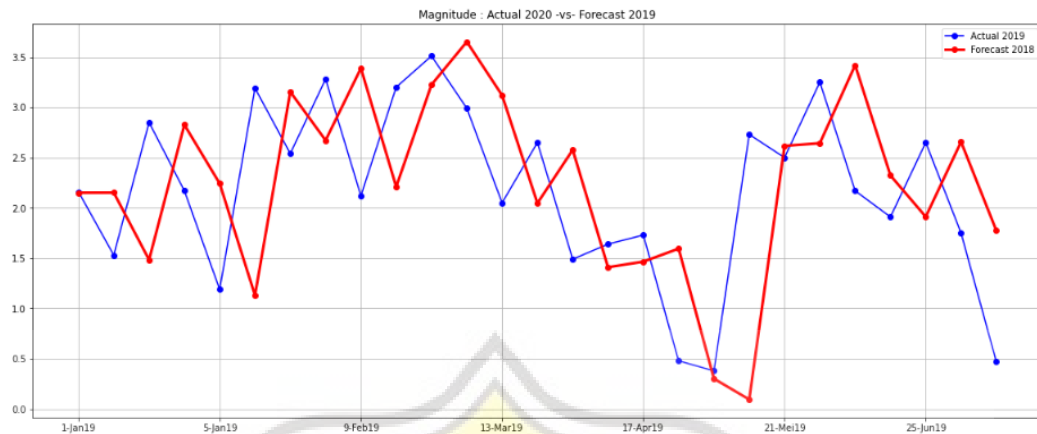


Figure 5.5 Comparison Graph of Predicted Results of Sumatra Island in 2018 and Actual Value in 2019

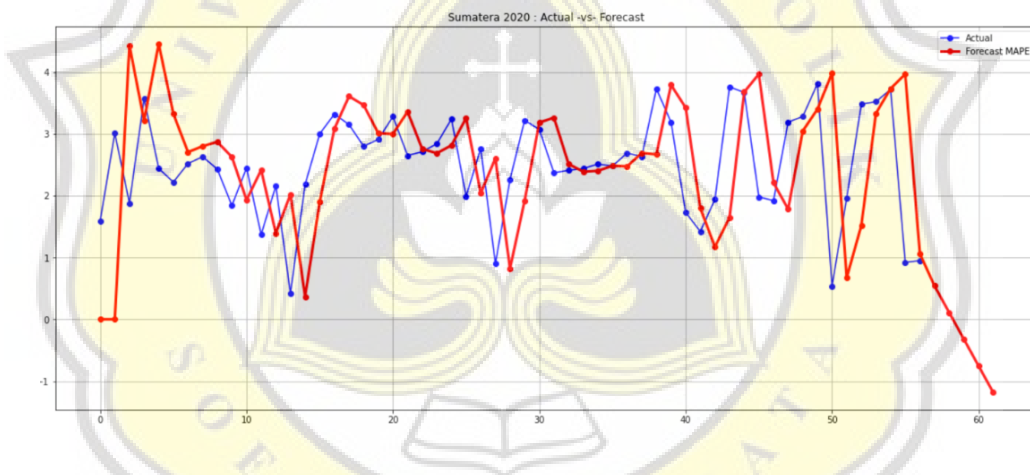


Figure 5.6 Graph of the Actual and Predicted Value of Sumatra Island in 2020

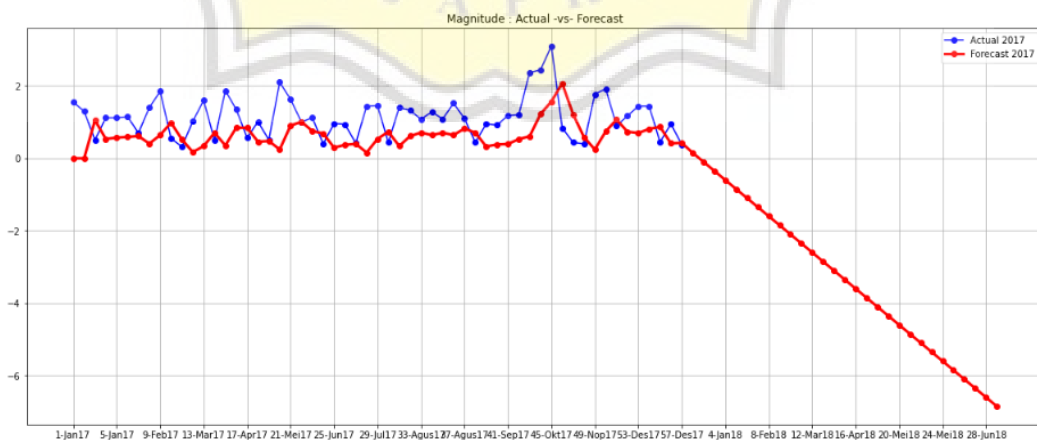


Figure 5.7 Graph of Bali Island Actual and Predicted Value in 2017

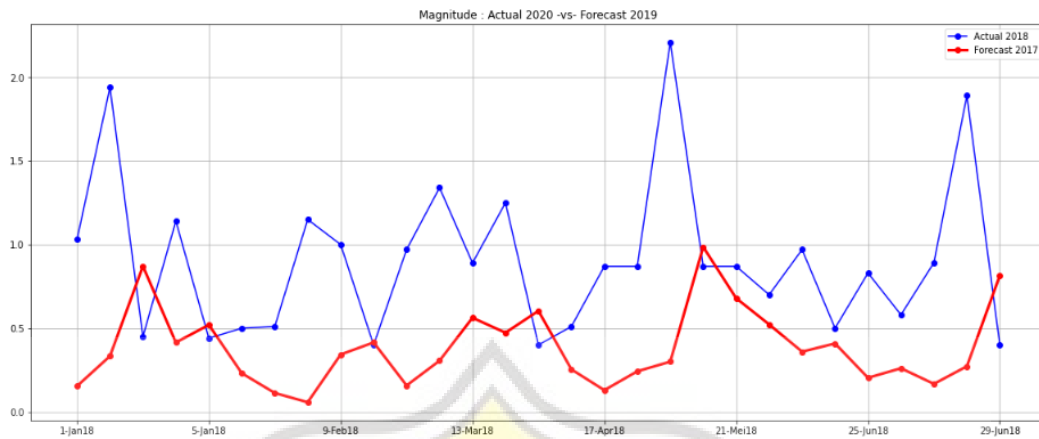


Figure 5.8 Comparison Graph of Bali Island Prediction Results in 2017 and Actual Value in 2018

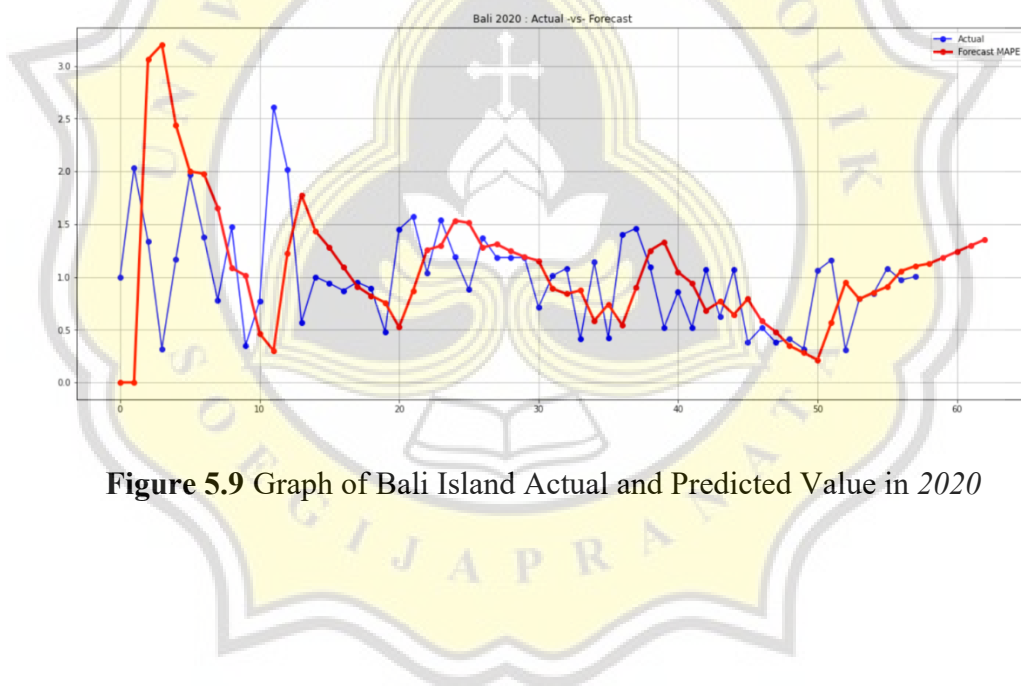


Figure 5.9 Graph of Bali Island Actual and Predicted Value in 2020