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PREDICTIONS OF RAINFALL DATA TO KNOW THE CONTENTS OF RESERVOIR USING THE HOLT-WINTERS EXPONENTIAL SMOOTHING MULTIPLICATIVE MODEL METHOD

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Abstract: *Rapid technology has given rise to new methods in science. Among these sciences, data prediction is a science that is often used to find out data on events that will appear in the future, one of which is forecasting discharge data. Water data that fills a reservoir can also be predicted by knowing past rainfall data that occurred in that area. This study aims to examine the water content of the Lowayu Reservoir by predicting past rainfall data to find out the rainfall that occurred in 2026. The results of the rainfall data prediction are then transformed into water discharge that will fill the reservoir and then be used to meet water needs for agriculture. The prediction method used is the Holt-Winters exponential smoothing model multiplicative method. The results of the study show that the highest rainfall was obtained in December - January 2024 - 2026 at 220 mm - 224 mm which resulted in a maximum water volume in the reservoir of 213,400,000 liters -217,280,000 liters/month during 2024-2026 with a Mean Average Percentage Error (MAPE) value of 15.8%*

INTRODUCTION

Rain is the result of a process of condensation of water vapor in the atmosphere which then becomes water droplets that are quite heavy and fall on the surface. Generally, rain occurs due to the cooling of air temperature or the addition of water vapor to the air (Perdana, 2015). Rain or precipitation is the descent of water from the atmosphere to the earth's surface. In tropical areas, rain provides the largest contribution so rain is often considered precipitation (Triatmodjo, 1998).

The incoming rainfall needs to be recorded continuously, it is very important to be used in engineering planning, especially for dam reservoir planning, and others. Therefore, recording rainfall data in an area must be done continuously. Even recording rainfall data in a watershed can be done at several points to find out the distribution of rainfall in the watershed (Cezar et al., 2021).

Rainfall data is very useful in providing information in various fields, one of which is irrigation in agriculture. In the field of irrigation, rainfall intensity is even predicted, this is to determine the amount of water discharge that will fill a reservoir. According to Sisinggih et al. (2020), the reservoir has the main function of storing water during the rainy season, and in the dry season, the water from the reservoir will be utilized optimally.

Lowayu Reservoir is located in Lowayu Village, Dukun District, which is approximately 40 km from the center of Gresik City. The reservoir, which was built in 1936, is expected to accommodate as much water as possible to be used by the surrounding population for irrigation. It should be noted that Lowayu Reservoir has the largest technical irrigation system in the Gresik Regency. The Lowayu Reservoir Irrigation System irrigates an agricultural area of 1445 Ha which is divided into 2 intake gates, intake 1 irrigates land with an area of 1213 Ha, and intake 2 irrigates land with an area of 232 Ha. The total area of the reservoir is 97 Ha, and under normal conditions, this reservoir can accommodate around 1,690,000 m^3 of water. The catchment areas of the two intakes cover 15 villages in the Dukun District, namely; The villages of Bangeran, Lowayu, Petiyin Tunggal, Tirem, Tebuwung, Mentaras, Madu Mulyorejo, Mojopetung, Ima'an, Sekargadung, Babak Bawo, Babak Sari, Kalirejo, and Sambogunung.

The availability of reservoir water for irrigation in the Lowayu area is highly expected, and high rainfall is expected to fill the reservoir so that it is sufficient for water needs during the planting season. Forecasting rainfall data in the coming year can help provide information on surplus or deficit in the condition of the reservoir contents. So that anticipation of cropping pattern planning can be rearranged according to the amount of water available. Furthermore, the results of rainfall data forecasting can also provide information on awareness of negative aspects caused by high rainfall intensity.

Based on the explanation, it is necessary to forecast the rainfall time series data for the next period. Forecasting of rainfall data can be done using a time series model with computer software. Research on rainfall prediction has also been conducted by other researchers including; Desvina and Ratnawati (2014), Harlina and Usman (2020), and Luthfiarta et al., (2020). Desmonda et al., (2018), Restianingsih and Kristiyanti (2023), and many other researchers.

Given the importance of knowing rainfall data in the future, this study discusses the problem of predicting rainfall in the local area of Lowayu Reservoir using the exponential smoothing method. To get an overview of the reservoir discharge data in the future, past rainfall data will be generated to find out future rainfall data. After the data is obtained, the next step is to transform the rainfall data obtained into discharge data, thus the total amount of available supply discharge in Lowayu Reservoir can be known. This study tries to examine and find the amount of discharge that will be available that can be used to meet the water needs of farmers. The purpose of this study is to analyze local rainfall data from predictions to meet water needs. And analyze the availability and release of water discharge in Lowayu Reservoir to meet agricultural water needs until 2026.

METHOD

The rainfall data obtained was immediately grouped and calculated using an Excel program on the computer. Furthermore, analysis was carried out using the Holt-Winters Exponential Smoothing (HES) software. HES is quite good for use with fluctuating data and is very relevant because the rainfall data currently obtained has a fluctuating pattern. In this method using a multiplicative model. Model analysis if the data plot showing seasonal

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fluctuations varies, then it will use a multiplicative model (Wei, 1994). The following are the analysis steps of the Holt-Winters exponential smoothing multiplicative model for level, trend, and seasonal equations (Sinay and SN Aulele, 2015):

a. Set the values (α), (β), and (γ) to 0-1 respectively.

b. Perform initial value calculations (initialization) for level smoothing(L_s)

$$L_s = \frac{1}{s}(Y_1 + Y_2 + Y_3 \dots \dots \dots + Y_s)$$

c. Perform initial value calculations (initialization) for trend smoothing ()b_s

$$b_s = \frac{1}{s}\{\frac{(Y_{s+1} - Y_1)}{s} + \frac{(Y_{s+2} - Y_2}{s} + \dots\dots + \frac{(Y_{s+s} - Y_s)}{s}\}$$

d. Performing initial-value calculations (initialization) on seasonal smoothing(S_s)

$$S_1 = \frac{Y_1}{b_1}, S_2 = \frac{Y_2}{b_2}, \dots\dots, S_s = \frac{Y_s}{b_s}$$

e. Calculate the smoothing level value using the formula:

$$L_t = \alpha \frac{Y_t}{S_t - s} + (1 - \alpha)(L_{t-1} + b_{t-1})$$

f. Calculate the trend smoothing value using the formula:

$$b_t = \beta(L_t - L_{t-1}) + (1 - \beta)b_{t-1}$$

g. Performing seasonal smoothing value calculations

$$S_t = \gamma \frac{Y_t}{L_t} + (1 - \gamma)S_{t-s}$$

h. Doforecasting for future periods

$$F_{t+m} = L_t + b_t m + S_{t-s+m}$$

Error value forecasting is measured about the actual value of the series using the MAPE method. The forecasting results will be more accurate if the percentage error value in MAPE is smaller. Here is the equation for calculating the MAPE value:

$$MAPE = \frac{\sum_{t=1}^{n} |PE_t|}{n} X100\%$$

RESULTS AND DISCUSSION

Lowayu Reservoir as a reservoir whose water discharge comes from rain, relies heavily on very high rainfall intensity to fill the reservoir. The availability of water sources for agriculture is a major challenge in Lowayu Village. Although there are other water sources (Sendang Biru), the discharge is not too large and is only enough to fill the spring itself for tourism. The existence of Bengawan Solo River is sometimes used to help with irrigation if the water level can reach the drainage channel. However, this happens very rarely. So agricultural land is very dependent on the Lowayu Reservoir whose source of content is rainfall. As a result, the amount of water for agricultural irrigation is limited.

For the sake of finding out information related to the condition of the Lowayu Reservoir water debit in the future, it is necessary to conduct a study related to rainfall that will occur in the future using the prediction method. As is known, rainfall data to predict the next rainfall requires quite long data. The rainfall data in Table 1 below will inform you of the amount of rainfall over the past 10 years, namely from 2013 to 2023.

Table 1. Rainfall (mm) in the Lowayu region

Month	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
January	253	244	253	123	160	382	293	263	64	332	317
February	134	186	134	208	134	271	132	290	32	171	220
March	159	120	159	133	156	300	303	184	45	267	133
April	208	154	208	83	164	37	213	292	30	259	175
May	201	97	201	228	83	2	24	196	52	158	62
June	216	30	216	167	280	26	2	1	10	61	2
July	114	49	114	63	52	2	34	11	0	180	37
August	2	2	2	28	2	2	2	79	5	41	2
September	2	2	2	126	26	13	2	3	17	10	2
October	19	2	19	126	44	28	2	72	51	120	2
November	92	107	92	150	275	131	49	135	59	141	160
December	175	146	175	234	229	194	139	561	55	264	120

Source: Gresik Regency Land Agency, 2023

Table 1 above shows daily rainfall data in millimeters (mm) recorded at the Lowayu Rain Gauge Station during the period 2013 to 2023. During the last 10 years, the highest rainfall was in November-May. This condition is indeed common because the conditions are in the rainy season, while the following month has entered the dry season.

This data also provides an overview of rainfall patterns in the Lowayu Reservoir area over the past ten years. The variation in rainfall from day to day can be seen in the table which can be used to analyze rainfall trends, identify the rainy and dry seasons, and support hydrological and climatological studies in the reservoir area. The purpose of knowing the upcoming rainfall is; (a) agricultural planning, so that farmers can use this data to determine the right planting time, set irrigation schedules, and choose the type of planting pattern that suits rainfall conditions, (b) water resource management; this data can be used to manage water resources more effectively, such as in planning the construction of dams, irrigation, and drainage systems, and (c) disaster mitigation; rainfall data can help in predicting potential hydrometeorological disasters such as floods and droughts.

Rain Data Prediction

Forecasting is a form of activity used to predict an event or something that will happen in the future. Where forecasting is only an estimate, but by carrying out certain techniques on a forecast, it can be said to be better than the previous estimate, and existing decision-making can be taken from existing forecasts. Forecasting is also done to reduce the uncertainty that will occur in the future (Qamal, 2019).

Many types of forecasting can be done, one of which is Exponential Smoothing. Many methods can be used to forecast, one of which is the Holt-Winters Exponential Smoothing Method, which can also be called Exponential Smoothing where the data used is time series data. The advantage of the Holt-Winters Exponential Smoothing Method is that it is very good at predicting seasonal data patterns, this method can also be said to be simple method and easy to put into practice and competitive with more difficult forecasting models (Safitri, Dwidayati, 2017).

The data forecasting used in this study forecasting is the Holt-Winters Multiplicative model method. This model was chosen because the data owned is data that has seasonal variations with a constant time series. The following are the stages of the Holt-Winters exponential smoothing multiplicative model analysis for level, trend, and seasonal equations (Sinay and SN Aulele, 2015):

a. Set the smoothing constants (α), (β), and (γ) to values of 0-1 each.
b. Calculating the initial values (initialization) of the smoothing level (L_s)
c. Calculating the initial values (initialization) of trend smoothing ()b_s
d. Calculating the initial values (initialization) of seasonal smoothing(S_s)
e. Countsmoothing level value
f. Counttrend smoothing value
g. Countseasonal smoothing value multiplicative model
h. Calculating future period forecasts

Model***hw. Multi*** is a useful tool for forecasting time series data with increasing seasonal components. By understanding the basic principles of the Holt-Winters method and how it works, this model can be applied to various relevant data prediction cases. Historical rainfall data from 2013-2023 obtained from the Gresik Regency Irrigation Service which will be used as the basis for prediction can be shown in Table 1 above.

This rainfall data is a data set used to build the model. This data has a seasonal pattern. "hw. Multi is a forecasting model that uses the Holt-Winters method with a multiplicative seasonal component. This model has been applied to time series dataRainfall data (ts)to predict 36 months (3 years). In the initial stage, make a data call with;

```
> library(forecast)
> hw.multi = hw(dataCH.ts, h = 36, seasonal = "multiplicative",
damped = FALSE, alpha = NULL, beta = NULL, gamma = NULL, phi = NULL)
> hw.multi$model
Holt-Winters' multiplicative method
Call:
hw(y = dataCH.ts, h = 36, seasonal = "multiplicative", damped = FALSE,
    alpha = NULL, beta = NULL, gamma = NULL, phi = NULL)
```

Figure 1. Data Preparation Source Code

In simple terms, this hw. Multi-model tries to predict the future based on patterns found in historical data, taking into account the presence of seasonal factors that become stronger as the data value increases. By entering the lowest values of alpha = NULL, beta = NULL, gamma = NULL, and phi = NULL, the smoothing of values for α, β, δ is obtained as follows:

```
Smoothing parameters:
    alpha = 0.0216
    beta = 0.001
    gamma = 1e-04

  Initial states:
    l = 164.7613
    b = -0.5977
    s = 1.9181 1.0311 0.4036 0.1305 0.0873 0.5058
           0.6434 0.9437 1.4076 1.5377 1.5013 1.8899
  sigma: 1.3781

AIC AICc BIC
1922.119 1927.487 1971.126
```

Figure 2. Source Code for Determining Alpha, Beta, Gamma and Sigma

AIC, AICc, and BIC are three information criteria that are often used in statistical model selection. AIC (Akaike Information Criterion) plays a role in measuring the balance between the model's goodness of fit and the model's complexity. Models with the lowest AIC tend to have the best balance between these two aspects. AICc (Corrected AIC) is a correction of AIC, especially useful when the sample size is relatively small. AICc imposes a greater penalty on complex models, so it tends to choose simpler models. BIC (Bayesian Information Criterion) is similar to AIC but imposes a greater penalty on complex models. BIC tends to choose simpler models than AIC. These three criteria help select the model that best fits the data from several alternative models. The lower the AIC, AICc, or BIC value, the better the model. This indicates that the model can explain the data well without being too complex. In this program, the AIC, AICc, and BIC values each have the lowest results, namely: AIC = 1922.119 AICc = 1927.487, and BIC = 1971.126, from these values the following results are obtained:

```
> hw.multi$fitted
     Jan        Feb        Mar        Apr        May        Jun       Jul       Aug       Sep       Oct       Nov        Dec
2013 310.257243 244.539788 246.940734 223.258604 148.731229 101.71439 81.636868 14.169122 20.675794 62.310463 155.897514 285.666543
2014 277.245800 218.155741 221.151469 198.923166 131.657341 88.514824 67.964177 11.546428 16.772527 50.206962 123.884804 226.653870
2015 218.445800 171.629530 172.362590 155.151727 103.222624 70.817757 57.465045 10.019829 14.514556 43.404815 108.021145 197.428273
2016 191.205507 148.387680 150.977242 135.727333 88.768622  61.670053 49.631595 8.505356  13.211927 48.316729 127.747375 238.592601
2017 235.044986 185.408558 188.675285 171.989433 115.151208 77.978526 64.818631 11.152691 16.362862 51.261630 130.677362 249.369771
2018 245.726890 198.004809 204.948466 190.094854 125.550067 83.918880 65.005903 10.976112 16.081176 49.421379 124.875815 232.126741
2019 227.498989 181.557914 184.506972 171.029507 115.182743 77.086897 59.113804 10.074028 14.717602 44.328748 110.176374 201.056412
2020 195.353673 155.234720 160.986433 146.923365 100.109819 69.416672 53.113382 8.953589  15.680236 47.630139 123.179113 229.846780
2021 234.125318 183.382950 184.645706 166.307117 109.472217 73.728563 56.742585 9.562703  14.098669 43.619741 111.515112 204.597494
2022 197.527079 158.624077 162.141058 150.049547 101.956808 70.232131 54.928649 9.956085  15.936249 48.987648 129.604484 242.543989
2023 240.459709 193.164483 199.339175 181.931953 122.393010 82.874908 63.926454 10.967158 16.093382 48.767598 121.913952 228.321338
```

Figure 3. Historical Data Source

In Figure 3, the existing data is displayed by the program to prepare the prediction process, and the results are point forecast, Lo80, Hi80, Lo95 and Hi95 as shown in Figure 4 below.

```
> print(hw.multi)
         PointForecast  Lo 80       Hi 80      Lo 95      Hi 95
Jan 2024 222.59001 -170.534900 615.71492 -378.64266 823.82268
Feb 2024 176.72340 -135.625140 489.07194 -300.97247 654.41927
Mar 2024 180.91746 -139.100635 500.93555 -308.50798 670.34289
Apr 2024 165.54638 -127.537295 458.63005 -282.68642 613.77918
May 2024 110.94408 -85.656294  307.54446  -189.73025 411.61842
Jun 2024 75.61317  -58.514196  209.74054  -129.51694 280.74328
Jul 2024 59.40660  -46.087212  164.90041  -101.93226 220.74545
Aug 2024 10.25543  -7.977321   28.48818   -17.62916  38.14002
Sep 2024 15.31942  -11.950351  42.58920   -26.38610  57.02495
Oct 2024 47.32899  -37.032245  131.69022  -81.69038  176.34836
Nov 2024 120.87055 -94.878857  336.61995  -209.08969 450.83078
Dec 2024 224.72783 -177.004917 626.46057  -389.66939 839.12504
Jan 2025 221.36616 -174.990224 617.72254  -384.80862 827.54094
Feb 2025 175.75129 -139.460903 490.96348  -306.32416 657.82673
Mar 2025 179.92181 -143.343344 503.18697  -314.46958 674.31321
Apr 2025 164.63491 -131.718017 460.98784  -288.59778 617.86760
May 2025 110.33296 -88.664388  309.33032  -194.00722 414.67315
Jun 2025 75.19647  -60.709191  211.10214  -132.65330 283.04625
Jul 2025 59.07906  -47.928857  166.08698  -104.57543 222.73355
Aug 2025 10.19886  -8.316032   28.71375   -18.11722  38.51495
Sep 2025 15.23488  -12.488201  42.95797   -27.16392  57.63369
Oct 2025 47.06768  -38.795012  132.93038  -84.24798  178.38334
Nov 2025 120.20290 -99.645361  340.05117  -216.02600 456.43181
Dec 2025 223.48595 -186.371089 633.34298  -403.33630 850.30819
Jan 2026 220.14279 -184.726131 625.01171  -399.05079 839.33638
Feb 2026 174.77956 -147.603236 497.16235  -318.26238 667.82149
Mar 2026 178.92657 -152.110538 509.96367  -327.35100 685.20413
Apr 2026 163.72380 -140.143627 467.59123  -301.00133 628.44893
May 2026 109.72209 -94.586753  314.03093  -202.74132 422.18549
Jun 2026 74.77994  -64.937189  214.49707  -138.89897 288.45886
Jul 2026 58.75166  -51.404077  168.90739  -109.71700 227.22032
Aug 2026 10.14232  -8.942935   29.22756   -19.04606  39.33069
Sep 2026 15.15038  -13.465661  43.76642   -28.61408  58.91483
Oct 2026 46.80648  -41.943676  135.55663  -88.92517  182.53813
Nov 2026 119.53553 -108.020931 347.09198  -228.48204 467.55310
Dec 2026 222.24455 -202.574862 647.06397  -427.46068 871.94979
```

Figure 7. Source of Prediction Results

The calculation results above can be explained by the display of the forecast results for January-December in 2024-2026. In addition to providing point forecast values, the table also provides prediction intervals at 80% and 95% confidence levels. The explanation of the column is:

- *Point Forecast*: The most likely forecast value or the best-estimated value for the period.
- *You 80*:The lower bound of the 80% prediction interval. This means that there is an 80% chance that the actual value is above this value.
- *Hi, 80*:The upper limit of the 80% prediction interval. This means that there is an 80% chance that the actual value is below this value.
- *You 95*:The lower bound of the 95% prediction interval. This means that there is a 95% chance that the actual value is above this value.
- *Hi, 95*:The upper limit of the 95% prediction interval. This means that there is a 95% chance that the actual value is below this value.

For example, the Interpretation for January 2024 can be explained as follows:

- *Point forecast*: The forecast value for January 2024 is 222.59. This is the most likely value based on the model used.
- 80% prediction interval: There is an 80% chance that the true value for January 2024 will be between -170.53 and 615.71.
- 95% prediction interval: There is a 95% chance that the true value for January 2024 will be between -378.64 and 823.82 and so on.

From this explanation, it can be concluded that the results of the rainfall data forecast for 2024-2026, using the help of R software to obtain optimal parameter values for the variables α, β, and γ where the values of $\alpha = 0.0216$, $\beta = 0.001$, and $\gamma = 1e\text{-}04$, and calculations were carried out using the Holt-Winters Exponential Smoothing method. Using a multiplicative model in accordance with the steps in the research method, the calculation results were obtained as shown in Table 2 as follows.

Table 2. Results of rainfall data forecasting (mm) 2024-2026

Year	Jan	Feb	Mar	Apr	May	June	Jul	Ags	Sep	Oct	Nov	Dec
2024	222	176	180	165	110	75	59	10	15	47	120	224
2025	221	175	179	164	110	75	59	10	15	47	120	223
2026	220	174	178	163	109	74	58	10	15	46	119	222

Table 2 explains that the predicted results for rainfall data in 2024-2026 have a maximum value of 224 mm falling in December 2024 and a minimum value of 10 mm in August throughout 2024-2026. More details can be seen in Figure 1 below.

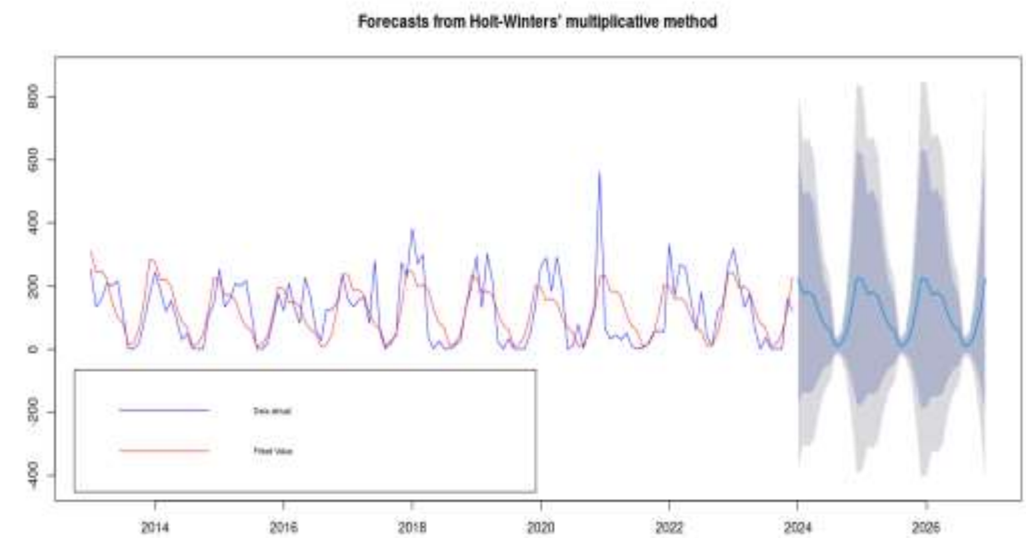

Figure 8. Rainfall prediction results 2024-2026

Figure 1 shows the forecasting results using the Holt-Winters method with a multiplicative seasonal component. The Blue line represents the actual data or actual historical data. This line shows how the data moves over time. The Red line is the forecasted value line (fitted value) from the Holt-Winters model. This line follows the general pattern of the actual data, showing how the model tries to fit the existing data. The shaded area (in Gray) is the area that represents the prediction interval. The darker part shows the prediction interval with a higher confidence level (95%), while the lighter part shows the prediction interval with a lower confidence level (80%). The prediction interval gives an idea of how confident the forecast is. Further interpretation of the graph is:

- The red line (forecast results) follows the general pattern of the blue line (actual data), indicating that the Holt-Winters model can capture patterns in the data, including trends and seasonality.
- The shaded area becomes wider as we approach the end of the graph (2024 and 2026) indicating that uncertainty in the forecast increases the further ahead we try to predict. This is common in forecasting because the further ahead we look, the more unknown factors there are that can affect the outcome.
- Repeating patterns in the data indicate a seasonal component. The Holt-Winters model with a multiplicative seasonal component is suitable for data with seasonal patterns whose amplitude is proportional to the data level.

In conclusion, the graph above shows that the Holt-Winters model has successfully captured patterns in historical data and produced forecasts for future periods. The prediction interval provides information about the level of confidence in the forecast.

Next, continue to calculate the error value of the prediction that has been done using MAPE. Mean Absolute Percentage Error (MAPE) is one of the many methods that can be used to calculate the accuracy value of a forecasting method and is also a relative determination to be able to determine the deviation of the error results from the predicted data with the actual data. The following is a formula that can be used in calculating MAPE (Utami & Atmojo, 2017). Following the equation above, the MAPE value is obtained as follows.

$$MAPE = \frac{\sum_{t=1}^{n} |PE_t|}{n} X100\%$$

$$= \frac{(100\%)}{36} X19{,}03156 = 15{,}859$$

Based on the calculations above, the error results from the calculation of the average rainfall prediction in the Lowayu Reservoir in 2024-2026 using the Holt-Winters Exponential Smoothing method using the Multiplicative Model are 15.859%, which means it can be stated as "good".Furthermore, to determine the reservoir volume each month originating from rainfall, Sri Dewi's (2019) equation theory is used, namely that rainfall of 1 millimeter (mm) is equivalent to 1 liter/m^2 which means that in a place of 1 square meter, there is an amount of water of 1 liter. It has been previously known that the area of the reservoir in the Lowayu Reservoir has an area of 97 ha or 970,000 m^2.

Based on the theory explained previously, the total discharge in the Lowayu Reservoir based on predicted rainfall data from 2024 to 2026 can be calculated using simple mathematics to find the reservoir water volume, for example in January 2024.

- Rainfall in January 2024 = 222 mm
- 1mm of rain on an area of 1 m^2 = 1ltr/m^2.
- Surface area of reservoir = 97 ha =970,000 m^2

- Fill the reservoir with water = 970,000x1x 222 = 215,340,000ltr
  = 215,340 m^3

Furthermore, the results of the calculation of the overall reservoir water content can be seen in Table 4.6 below.

Table 3. Prediction results of the contents of the Lowayu Reservoir in 2024-2026

Prediction of the Contents (m^3) of the Lowayu Reservoir 2024-2026												
Year	Jan	Feb	Mar	Apr	May	June	Jul	Ags	Sep	Oct	Nov	Dec
2024	215340	170720	174600	160050	106700	72750	57230	9700	14550	45590	116400	217280
2025	214370	169750	173630	159080	106700	72750	57230	9700	14550	45590	116400	216310
2026	213400	168780	172660	158110	105730	71780	56260	9700	14550	44620	115430	215340

Table 3 shows the calculation results for the prediction of the contents of the Lowayu reservoir in 2024-2026. These results explain that the maximum reservoir contents occur in January - December, namely between215,340,000 liters – and 217,280,000 liters, and the minimum reservoir content occurs in August 2024-2026 amounting to 9,700,000 liters. Overall, if totaled per year, the contents of the Lowayu reservoir are respectively in 2024 = 1,360,910,000 liters, 2025 = 1,356,060,000 liters, and 2026 = 1,346,360,000 liters.

CONCLUSION

The Holt-Winters model graph captures the pattern of historical data and produces a forecast for the future period. The prediction interval provides information about the level of confidence in the forecast. This is indicated by the forecast results following the general pattern of the actual data, indicating that the Holt-Winters model can capture patterns in the data, including trends and seasonality. Furthermore, the shaded area becomes wider as it approaches the end (2024 and 2026) indicating that the uncertainty in the forecast increases the further ahead in trying to predict. However, the repeating pattern in the data indicating the seasonal component makes the Holt-Winters Model with a multiplication seasonal component suitable for data with a seasonal pattern whose amplitude is comparable to the data level. By using the help of R software, the optimal parameter values $\alpha = 0.0216$, $\beta = 0.001$, and γ = 1e-04 were obtained, and calculations were carried out using the Holt-Winters Exponential Smoothing method, so the Forecast Results are categorized as good. This is evidenced by the deviation of the predicted data error results with the actual data with a Mean Absolute Percentage Error (MAPE) value of 15.8%. Furthermore, from the results of the data forecast, the reservoir contents are predicted to have a water volume the maximum occurs in January – December, namely between215,340,000 liters – 217,280,000 liters, and the minimum reservoir content occurs in August in 2024-2026 amounting to 9,700,000 liters. Overall, if totaled per year, the contents of the Lowayu reservoir are respectively in 2024 = 1,360,910,000 liters, 2025 = 1,356,060,000 liters, and 2026 = 1,346,360,000 liters.

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