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Comparison of Holt Winters and Simple Moving Average Models to Identify The Best Model for Predicting Flood Potential Based on The Normalized Difference Water Index.

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Abstract – Flood is a condition in which water cannot be accommodated in a drainage channel such as a river or river. An area is said to be flooded if the water in the area is inundated in large quantities so that it can cover all or most of a large area. Determining forecasting or prediction on a potential in the long or short term, especially changes in water content levels in an area, requires a method, model, or approach that must be well tested. The lower the error value in a model, the better the model for testing a forecast. One of the data that can be used for analysis of potential flood models is the use of remote sensing data with technology from Landsat 8. The advantage of sensing data from Landsat 8 is that it has data good history and allows to see changes in land cover from year to year in an area. The purpose of this study was to determine the best model for forecasting the potential for flooding in an area using the Holt Winters model and the Simple Moving Average. The result of this research is that the RMSE, MAE, MAPE, MSE values in the Holt Winters model are 0.03598683, 0.02748707, 0.13944356, 0.00129505 while the RMSE, MAE, MAPE, MSE values on the Simple Moving Average are 0, 09681483, 0.06338657, 0.53775228, 0.00937311. The Holt Winters model is the best model of the Simple Moving Average because the forecast error value has a low value.

Keywords: Flood, Forecasting, Holt Winters, Simple Moving Average, NDWI

I. INDTRODUCTION

The current rate of global warming is extremely concerning. Flooding is one of the many natural disasters that have struck Indonesia as a result of the effects of global warming. A flood is a condition in which a region is inundated by large quantities of uncontrolled water flow, which inundates or strikes a region or settlement because the river cannot accommodate the overflowing water. Two factors can contribute to the occurrence of floods: natural factors and human factors[1], [2].


Sumber : Badan Nasional Penanggulangan Bencana (BNPB), 18 Juni 2021

Figure 1. Disaster Data according to BNPB

Flood disasters can be predicted by monitoring precipitation and water flow. In addition to heavy rainfall, soil texture, land slope, and land use can also contribute to flooding. In general, floods frequently occur near watersheds. Sometimes, heavy precipitation can cause river reservoirs to exceed the volume of the river, leading to flooding.

Using remote sensing data from Landsat8 and the Normal Difference Water Index model to analyze the flood potential model is one of the data that can be used. Based on calculations from previous remote sensing research titled (Development of an Inundated Area Identification Model Using Landsat[3] , the NDWI variable has a good ability to detect flood inundation. The benefits of remote sensing data include accurate historical information and the ability to observe annual changes in a region's land cover. The area coverage of the extensive remote sensing data enables a comprehensive view and analysis of the area, allowing the primary causes of flooding to be identified. This information can also be used as input for modeling potential flood zones.

Several previous studies related to forecasting using the Simple Moving Average [4] with the title (Prediction of PDAM Water Usage Using the Simple Moving Average Method) explained that this SMA was able to provide good predictive results, namely the MAPE value of 0.1712, where if the MAPE value is 10%, then the prediction results are categorized as good, as well as for related research for the Holt With values of = 0.1, = 0.001, and =0.5, the Holt-Winters method[5] yields better results than the SSA method with a MAPE of 13.469 percent.

Researchers are interested in developing research using Landsat 8 data with the NDWI (Normalized Difference Water Index) [6]feature and comparing the Simple Moving Average and Holt Winters models to determine the best model for making predictions based on previous research. In order to compare the two methods optimally, researchers will compare evaluation values including MAE, MAPE, MSE, and RMSE. Landsat 8's resolution is ideal for detecting, measuring, and analyzing changes in earth's surface objects at a granular level.

Landsat 8 is utilized because it is able to produce images for flood detection data processing[7]. The Normalized Difference Water Index (NDWI) feature is used to detect bodies of water. NDWI is a remote sensing-based identification method that is sensitive to changes in water content, according to publications [8] stating that an NDWI value greater than or equal to 0 indicates the water surface, whereas a value less than or equal to 0 indicates non-water level. The data that will be collected and used to predict potential flooding is based on two years of historical Landsat 8 data.

II. RESEARCH METHODOLOGY

According to a study by Sulistyanto [9] load cells are commonly used to measure force and torque. The load cell sensor will deliver accurate and dependable results when the load cell is used properly. The results of research and observations using the Level Two SMA Method and the Level Two WMA Method indicate that both methods have the ability to reduce sociation well; however, the Level Two SMA method is superior to the Level Two WMA method in determining the reference point, as the reference point search is based on the data value when the load cell is stable. When conditions are stable, the standard deviation of the Level Two SMA Method and the Level Two WMA Method is 0.015572.

This study aims to predict monthly rainfall in Ambon City using the Holt-Winter Exponential Smoothing method [10]. This study makes use of monthly precipitation data from January 2005 to December 2016. The data is the result of observations made at the Ambon Meteorological, Climatology, and Geophysics Agency's Meteorological Station. According to data analysis, monthly precipitation in Ambon City follows a seasonal pattern. The results of this study indicate that the Holt-Winter model based on the seasonal multiplication method is a suitable model for forecasting monthly rainfall data in Ambon City due to its low SSE/RMSE value. The Holt-Winter model predicts that precipitation in Ambon City will increase next year.

In a study to compare the forecasting accuracy of the Holt Winters method and the Singular Spectrum Analysis model (SSI) [11],the difference in methods undoubtedly affects the accuracy of the predicted outcomes. The distinction between the three methods is determined by comparing the accuracy and dependability of the forecast results. Mean Absolute Percentage Error (MAPE) is used to measure the accuracy of forecasting, and tracking signal is used to measure the dependability of forecasting results. The application concerned the production of shallots in Indonesia from January 2006 to December 2015. Forecasting the two SSA methods using L=39 and r=8 grouping windows. With values of = 0.1, = 0.001, and =0.5, the Holt-Winters additive method produced better results than the SSA method with a MAPE of 13,469 percent.

According to research [12], the Simple Moving Average is a predictive model. The moving average technique is employed to forecast demand by calculating the average value and actual demand value from a predetermined number of previous periods. As implied by the method's name, each new prediction is fixed to the previous period and used with requests from the new period, so the data used in the calculation changes over time. The simple moving average method is utilized for unstable, trendless, and unweighted data. With the simple moving average method, which is one method for predicting system models based on time series with computerized characteristics, regarding predicting carpets, it is anticipated that the carpet laundry company will be able to predict the monthly income of the carpets in order to calculate the monthly profit ratio. In order to develop a user-friendly system for predicting the profit of a successful carpet cleaning business.

In a study authored by Laurensz [13] Floods are the most prevalent natural disasters in nearly all regions, and they can cause destruction, loss, and even loss of life. Volcanoes, archipelagos, and severe environmental degradation characterize this region. Standardized Precipitation Index (SPI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Soil Adjusted Vegetation Index (SAVI), and Inverse Distance Weighted (IDW) are the analysis methods used in this study for data exploration with Quantum GIS (QGIS). In Manado during the rainy season, the NDVI value or greenness level of the vegetation index ranges from 0.451 to 0.639, indicating a high greenery vegetation index. And during the dry season, the index is between 0.44 and 0.61, indicating a high level of green vegetation. Using the NDWI method, it was determined that the level of wetness in Manado was moderate. According to the SAVI method, Manado has a range of values between -0.103 and 0.153, which indicates an abundance of puddles. According to the discussion, the subdistricts with the greatest potential for flooding in the city of Manado are Tuminting, Singkil, Paal Dua, Tikala, Wanea, Sario, Weneang, and Malalayang. Medium potential exists in the Bunaken District, while Mapanget District has little potential.

The results of the review of the five journals have some bearing on the similarities and differences in research[13]. In this study, remote sensing data or Landsat 8 technology were used to conduct research on an object or area. The benefits of sensing data from Landsat 8 include the availability of accurate historical data and the ability to observe changes in land cover from one year to the next. The NDWI (Normal Difference Water Index) variable has a strong ability to detect flood inundation[14].

In addition to a literature review, research utilizing the Simple Moving Average model demonstrates that SMA can be applied to the forecasting process due to the implementation of a relatively simple algorithm utilizing a number of actual data requests. new method for generating future demand forecast values. According to the Holt Winters model research published by Sinay, Pentury, and Anakotta (2017) the Holt-Winter method is a development of a simple exponential smoothing method that employs three smoothing constants: the constant for smoothing the entire level, the constant for smoothing the trend (trend), and the constant for smoothing the season (seasonal).

III. RESEARCH METHODOLOGY

A. Analysis Techniques

In this analysis technique, researchers attempt to explain how the model process for solving a problem flows, so as to facilitate understanding of a model to be created. The analysis process is supported by collected data such as observations, literature studies, and Landsat 8 images of land objects[15]. In order to obtain the necessary specifications for this study, the several steps of the analysis procedure are as follows:

1. Collecting image object data from the USGS website using Landsat 8 technology from 1 May 2019 to 1 April 2021.
2. Performing Preprocessing of Data by Clipping Typically, a satellite image has a coverage area that is too large to reflect the research area. To obtain a representation of the research area, it is necessary to clip the data, also known as clipping. The image that has been clipped using the QGIS application is transformed with NDWI to produce a water index or wetness index.
3. Visualize for forecasting the likelihood of high inundation or flooding based on the accuracy of the NDWI value using the Simple Moving Average and Holt Winters methods.
4. The final step is to evaluate the error stage by specifying values like RMSE, MAE, MAPE, and MSE (Mean Squared Error)

B. Design Techniques

At this stage, a system with the concept of an information retrieval system that can forecast the potential for flooding in an area and determine the best model from the Holt Winters model and the Simple Moving Average through evaluation tests will be developed. Figure 2 depicts an overview of the system that will be constructed.

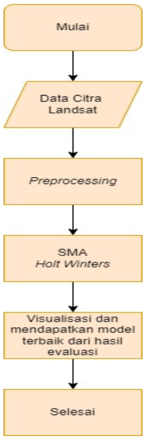


Figure 2. System Design Flowchart

C. Data Collection Method

During the research phase, data research becomes a critical element. Therefore, every researcher must comprehend the appropriate data collection techniques for the type of study being conducted[16].

1. Observation

   Observations were made through direct observation of the research object. In this study, researchers used Bekasi as a single example of a location area. Using coordinates 6°14′06″S 106°59′32″E, it was determined that the research was conducted in the province of West Java. Figure 3 depicts the urban region of Bekasi.

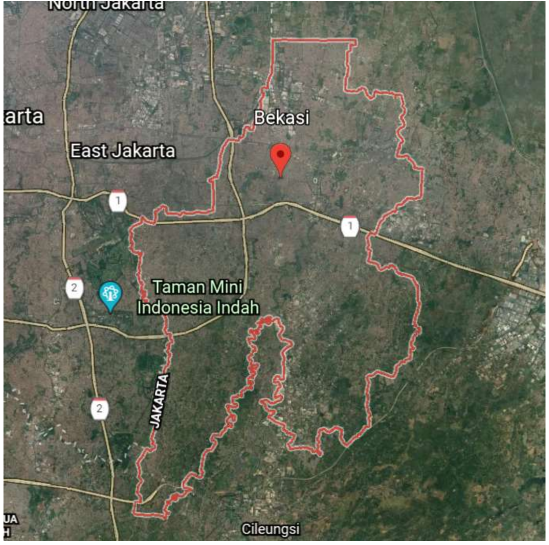


Figure 3. Area of Bekasi City

   In general, the Bekasi City region has a tropical monsoon climate (Am) with a high humidity level of 78 percent. The daily climate conditions are extremely warm. This is particularly influenced by increased land use, particularly industry or commerce and human settlements. The estimated daily air temperature ranges between 24 °C and 33 °C. Bekasi City experiences two seasons due to its tropical monsoon climate: the rainy season and the dry season. The dry east-southeast monsoon influences the dry season in Bekasi City from early May to September, with August being the driest month. Meanwhile, the rainy season in Bekasi is influenced by the wet and humid southwest-northwest monsoon, which typically blows from November to March, with the peak of the rainy season occurring in January with more than 300 mm of rainfall per month (wikipedia).

2. Secondary Data

   Secondary data is supplementary data obtained from research data sources through intermediary media or indirectly in the form of books, records, existing evidence, or archives, whether published or unpublished. This study's secondary data is comprised of literature studies from national and international journals and news articles from related websites. There are numerous supporting evidences. Researchers make use of precipitation data as secondary data. May 2019 to

April 2021 weather information retrieved from the website https://id.weatherspark.com (2 years). The weather and precipitation data can be found in table 1 below.

Table 1. Rainfall and Weather

	Curah Hujan	Curah Hujan /mm	Cuaca / Celcius
1	May-19	104	30
2	Jun-19	65.1	29
3	Jul-19	52.5	29
4	Aug-19	45.3	29
5	Sep-19	53.7	29
17	Sep-20	63.5	30
18	Oct-20	98	29
19	Nov-20	160	29
20	Dec-20	209.5	29
21	Jan-21	287.5	27
22	Feb-21	279	28
23	Mar-21	180.1	29
25	Apr-21	148.2	30

D. Testing Techniques

At this stage, the researcher will test or evaluate the constructed model in an effort to ensure that the model's execution is consistent with the research objectives. Scoring of RMSE (Root Mean Squared Error), MAE (Mean Absolute Error), and MSE (Mean Squared Error) is performed to determine the level of performance of the Simple Moving Average and Holt Winters models [17] applied to the dataset (Mean Squared Error). to obtain the ideal model.

IV. RESULT AND DISCUSSION

A. Data Collection

The primary data used by the author in this study are satellite images obtained by downloading data from https://www.usgs.gov between 1 May 2019 and 1 April 2021.

B. Preprocessing

After retrieving Landsat 8 image data, the data preprocessing stage is carried out. From the previous stage, it did not accurately represent the case study area, so it required further adjustments using clipping techniques; QGIS was used for the clipping stage. as displayed in image 4 below,

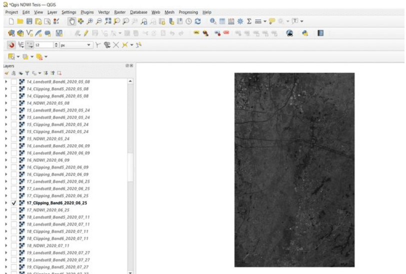


Figure 4. Clipping stage

When the clipping process is complete, the modeling stage, namely the transformation stage to obtain a water index with the NDWI (Normal Different Water Index) feature, is executed. Using QGIS, satellite images that have undergone the clipping procedure are processed. Can be seen in Figure 5,

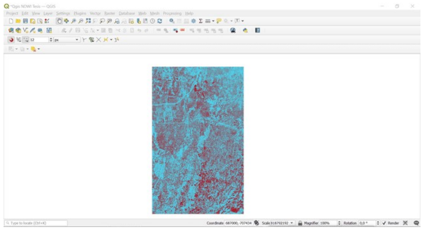


Figure 5. NDWI Layer Stacking Extraction Results on May 2019

After preprocessing, the Normalized Difference Water Index (NDWI) method is used to extract features. The level of validity in the research area is determined by transforming QGIS-processed raster data using the NDWI algorithm. Two spectral colors, namely red and blue, are assigned to raster data that has been modeled using NDWI. As shown in Figures 6, 7 and 8 below, the blue color represents land that has an ari value or a high level of water value validity, while the red color represents land that does not have a valid value.

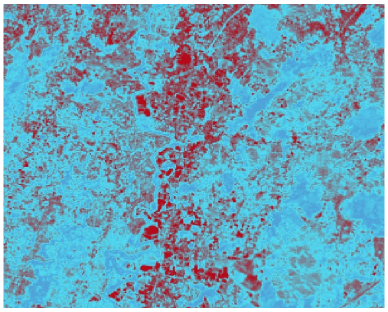


Figure 6. NDWI Results on May 2019

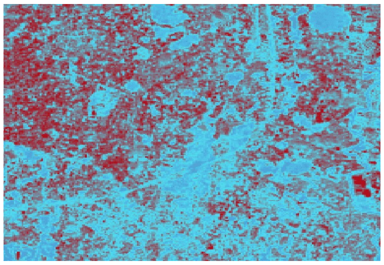


Figure 7. NDWI Results July 2019

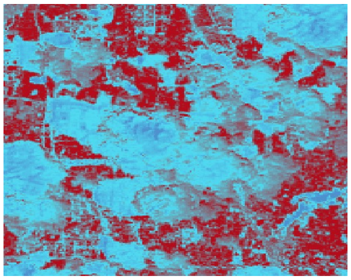
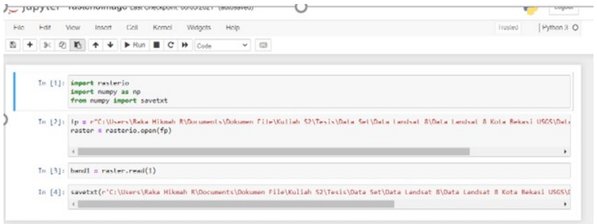


Figure 8. NDWI Results August 2020

After obtaining the image from the Normal Difference Water Index extraction feature, it is necessary to rasterize the NDWI image using Python. Figure 9 demonstrates how data can be incorporated into a model, as demonstrated.



```
In [1]: import rasterio
        import numpy as np
        from numpy import savetxt

In [2]: fp = r"C:\Users\Raka Hikmah R\Documents\Dokumen File\Kuliah S2\Tesis\Data Set\Data Landsat 8\Data Landsat 8 Kota Bekasi USGS\Dat
        raster = rasterio.open(fp)

In [3]: band1 = raster.read(1)

In [4]: savetxt(r'C:\Users\Raka Hikmah R\Documents\Dokumen File\Kuliah S2\Tesis\Data Set\Data Landsat 8\Data Landsat 8 Kota Bekasi USGS\D
```

Figure 9. NDWI Raster Process

After completing the raster, a.csv file will be generated, as shown in Figure 10.

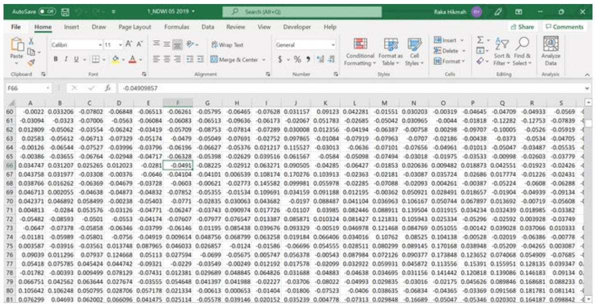
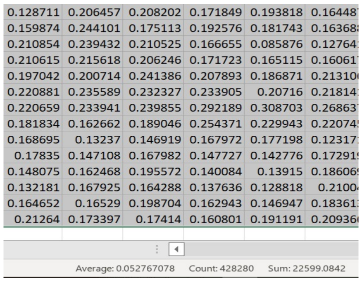


Figure 10. NDWI Raster Results on May 2019

From May 2019 to April 2021, a total of twenty-four data periods will be utilized. 1 period consists of 517 columns and 830 rows, with a total of 12,408 columns and 19,920 rows in each excel file containing 248,167,360 data points. The obtained data consists of a set of numbers representing each color pixel that has undergone the raster data process. Therefore, it is necessary to calculate the data in order to determine the average value of each period prior to processing the data.

After obtaining the raster's output data, search for the average value for each period of the raster's data. The data must be calculated to determine the average value for each period before they can be processed. Figure 11 illustrates this.



0.128711	0.206457	0.208202	0.171849	0.193818	0.16448
0.159874	0.244101	0.175113	0.192576	0.181743	0.16368
0.210854	0.239432	0.210525	0.166655	0.085876	0.12764
0.210615	0.215618	0.206246	0.171723	0.165115	0.16061
0.197042	0.200714	0.241386	0.207893	0.186871	0.21310
0.220881	0.235589	0.232327	0.233905	0.20716	0.21814
0.220659	0.233941	0.239855	0.292189	0.308703	0.26863
0.181834	0.162662	0.189046	0.254371	0.229943	0.22074
0.168695	0.13237	0.146919	0.167972	0.177198	0.12317
0.17835	0.147108	0.167982	0.147727	0.142776	0.17291
0.148075	0.162468	0.195572	0.140084	0.13915	0.18606
0.132181	0.167925	0.164288	0.137636	0.128818	0.2100
0.164652	0.16529	0.198704	0.162943	0.146947	0.18361
0.21264	0.173397	0.17414	0.160801	0.191191	0.20936

Average: 0.052767078 Count: 428280 Sum: 22599.0842

Figure 10. Calculation Results of the Average Value

C. Data Preparation

Following the completion of the hold preprocessing, the data for the Simple Moving Average and Holt Winters models must be prepared. Following are data from each period based on the outcomes of the preprocessing procedure detailed in table 2.

Table 2. NDWI data for the whole period

	Nilai NDWI	Bulan-Tahun	Periode
1	0,05276708	May-19	1
2	0,11557148	Jun-19	2
3	0,05525897	Jul-19	3
24	0,09001209	Apr-21	24

D. Calculation of Holt Winters

This is a forecasting model for data with trend and seasonal patterns. The initial step in forecasting is determining the initial value (the overall smoothing value) or calling the level. This procedure involves substituting the value from the previous year.

So as to:

$$\begin{aligned} L_{12} = \frac{1}{12} &+ (0{,}05276708 + 0{,}11557148 \\ &+ 0{,}05525897 + \cdots \\ &+ 0{,}11043278 \\ &+ 0{,}09001209) \\ L_{12} &= 0{,}10356897 \end{aligned}$$

After that, the level value in the 12th period was 0.10356897. After locating the initial value of the seasonal component (St) for the period 1 through 12, the value for the component period 1 through 12 is determined:

$$\begin{aligned} St_1 &= 0{,}05276708 \div 0{,}10356897 \\ &= 0{,}50948737 \\ St_2 &= 0{,}11557148 \div 0{,}10356897 \\ &= 1{,}11588910 \\ St_3 &= 0{,}05525897 \div 0{,}10356897 \\ &= 0{,}53354757 \end{aligned}$$

After obtaining the initial value, a search is conducted for the overall smoothing value. From trend, level, and seasonal data, it is possible to estimate the parameter values to minimize errors based on previous experiments. The alpha constant value = 0.2, gamma = 0.2, and beta = 0.1 are constants for trend smoothing, level smoothing, and seasonal smoothing, respectively.

24 period

$$\begin{aligned} L_{24} &= 0{,}2 \times (0{,}09001209 \div 1{,}01085039) \\ &\quad + (1 + 0{,}2) \\ &\quad \times (0{,}12244737 + 0{,}0004584) \\ &= 0{,}11613379 \\ b_{24} &= 0{,}1 \times (0{,}11613379 - 0{,}12244737) \\ &\quad + (1 - 0{,}1) \times 0{,}0004584 \\ &= -0{,}0002188 \\ S_{24} &= 0{,}2 \times (0{,}09001209 \div 0{,}11613379) \\ &\quad + (1 - 0{,}2) \times 1{,}01085039 \\ &= 0{,}96369479 \\ F_{24} &= (0{,}12244737 + -0{,}0004584) \times 1{,}01085039 \\ &= 0{,}12423934 \end{aligned}$$

After making a forecast for the period 1 to 24, the next step is to make a forecast for the next three months. The resulting value is as follows:

25 period

$$F_{25} = (\,0{,}11613379 + (1\ \times -0{,}0002188)\ \times 0{,}50472699 = \ 0{,}05850542$$

26 period

$$F_{26} = (\,0{,}11613379 + (2\ \times -0{,}0002188\,)\ \times 1{,}08147029\ = \ 0{,}12559524$$

27 period

$$F_{27} = (\,0{,}11613379 + (3\ \times -0{,}0002188\ )\ \times 0{,}54681018 = \ 0{,}06350314$$

Table 3. Holt Winters Method

Periode	NDWI	Level	Trend	Seasonal	Forecast
May-20	0,04972123	0,10356897	0	0,50472699	0,05276708
Jun-20	0,09292387	0,10237331	-0,0001196	1,08147029	0,11410384
Jul-20	0,06064582	0,09845768	-0,0004992	0,54681018	0,05226552
Feb-21	0,20777327	0,13006087	0,0015019	1,67770143	0,22323101
Mar-21	0,11043278	0,12974074	0,0013197	1,18436569	0,16447917
Apr-21	0,09001209	0,12244737	0,0004584	0,96369479	0,12423934

After calculating with NDWI data and the results of precipitation and weather forecasting data using the Holt Winters method, as shown in table 3, the results are presented.

E. Calculation of Simple Moving Average

Using a number of new actual demand data to generate forecast values for future demand is how the Simple Moving Average algorithm (moving average) is used for forecasting (M. S. Putra & Solikin, 2019). Simple moving averages are a straightforward method for forecasting (M. S. Putra & Solikin, 2019). SMA is quite effective in determining the current trend despite its simplicity.

To find a forecast, one must first determine the initial value. This process is carried out by substituting the value of the previous year or the first 12 periods with the value of the thirteenth forecast until the following value is obtained:

period 13

$$F_{13} = \frac{1}{12} + (0{,}05276708 + 0{,}11557148 + 0{,}05525897 + \cdots + 0{,}17573213 + 0{,}12997773 + 0{,}10469273)$$

$$L_{13} = 0{,}10356897$$

24 period

$$F_{25} = \frac{1}{12} + (0{,}10469273 + \ 0{,}04972123 + \ 0{,}09292387 + \ \ldots + 0{,}13482051 + 0{,}04972123 + 0{,}11043278\,)$$

$$L_{25} = \ 0{,}11203308$$

After making a forecast for the period 1 to 24, the next step is to make a forecast for the upcoming 1 month forecast. The value obtained is as follows:

25 period

$$F_{25} = \frac{1}{12} + (0{,}04972123 + \ 0{,}09292387 + 0{,}06064582 + \ \ldots + 0.08777 + 0.05043 + 0.08001\,)$$

$$L_{25} = 0{,}11080970$$

F. Comparison of Holt Winters Model and Simple Moving Average

The forecasting results of the Holt Winters and Simple Moving Average models are shown in Table 4 below.

Table 4. Comparison Holt Winters and Simple Moving Average

Periode	**NDWI**	***Holt Winters***	***Simple Moving Average***
May-20	0,04972123	0,05276708	0,10356897
Jun-20	0,09292387	0,11410384	0,10331515
Jul-20	0,06064582	0,05226552	0,10142784
Feb-21	0,20777327	0,22323101	0,11099173
Mar-21	0,11043278	0,16447917	0,11366183
Apr-21	0,09001209	0,12423934	0,11203308

V. CONCLUSION

According to the findings of comparative research between the Holt Winters model and the Simple Moving Average, it can be concluded that:

1. The Holt Winters model's RMSE, MAE, MAPE, and MSE values are known to be 0.03598683, 0.02748707, 0.13944356, and 0.00129505, while the Simple Moving Average's values are 0.09682125, 0.06338657, 0.53775228, and 0.00937311.

2. The smaller the forecast error value, the more effective the model implementation.
3. The Holt Winters model is the superior model of the Simple Moving Average due to the day's low forecast error value.

In this study, 1 period's worth of image data is sufficient for 1 period's size, which is 900 MB. In this study, 24 periods (2 years) of image data were used, resulting in an image data size of 21,6 GB.

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