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Application of the Single Exponential Smoothing Method For Flood Disaster Prediction

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ABSTRACT

The country of Indonesia is seen as one that is particularly vulnerable to natural catastrophes as well as calamities brought on by human activity. A disaster that may be brought on by both natural and human sources is a flood. Disasters brought on by flooding are unpredictable occurrences that frequently cause losses in the form of property damage, the theft of assets, and lost productivity at work and in school. Through this prediction information system, the people can find out the level of risk of flooding through excessive rainfall. in order to better anticipate and prepare for all possibilities that occur before the flood, the method used is Single Exponential Smoothing. This method was chosen because of the simple way the system works to find predictive values through past data. With this system, researchers can input rainfall data taken from the Meteorology, Climatology and Geophysics Agency, then the data is processed through the system and if rainfall gets high results. The risk of flooding will also be very high and a warning will be given to the public so that better prepared for the risk of flooding. The results obtained from this study are the results of an analysis of the exponential method single to obtain accurate rainfall prediction information with data MAD, MSE and MAPE.

Keywords: Application; flood; prediction; rainfall data; single exponential smoothing

INTRODUCTION

Flood is an event that becomes the topic of news every year. During the rainy season, many cities in Indonesia experience floods. Many efforts have been made by the government, including building dams, building canals, and reforestation of forests, but nothing has solved the problem. In fact, it seems that the scope is getting wider, both in frequency, extent, depth, and duration. Floods are caused by two factors, namely natural factors and factors caused by human activities (Suripin, 2004). Flood disasters are natural disasters that are almost certain to occur every time the rainy season arrives. As happened in Sigi Regency, Central Celebes, flooding occurred due to runoff from the river which spread to residents' homes.

The Meteorology, Climatology and Geophysics Agency is an institution that has the task of carrying out government duties in the fields of meteorology, climatology and geophysics in the territory of Indonesia. One of the duties of the BMKG is to provide information and early warning to related agencies and parties and the public regarding disasters due to meteorological, climatological and geophysical factors. The factors that contribute to flooding disasters include overuse of groundwater, which raises ground levels, and the amount of pollutants in waterways and reservoirs, such as rivers or reservoirs, which makes them unable to hold large amounts of water from exceptionally heavy rains (Nurrijal et al., 2021).

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However, in the process of submitting information there are often delays so that the people in Sigi Regency cannot anticipate the occurrence of a flood disaster so that residents experience quite severe losses, such as the incident that occurred some time ago, Saturday, August 8 2020, in Kulawi District due to rainfall. which reached more than 300 millimeters which caused quite severe water overflow causing rainfall and land that was swept away by the flood currents and resulted in quite severe losses due to the lack of anticipation of the residents of Sigi Regency, especially in Kulawi District.

To solve the problem in order to anticipate future floods, it is necessary to create an information system for notification of flood disaster predictions using rainfall data collection at the Meteorology, Climatology and Geophysics Agency (BMKG) office. Using the Single Exponential Smoothing method, which is a fairly good forecasting method for forecasting long term and medium term, so residents can see updated information every month, in order to help residents reduce losses due to floods that often hit the Sigi Regency area.

LITERATURE REVIEW

Based on pertinent information from the past, forecasting techniques are a quantitative way to predict what will happen in the future (Abdurrahman et al., 2017). This approach is very helpful in conducting an analysis of the behavior or patterns of historical data in order to provide more systematic, practical thinking, workmanship, and solutions. Flood forecasting is essential for managing urban flooding because it is effective at both preventing flooding and minimizing damage (Keum et al., 2020).

Research conducted by L. J. Sinay, Th. Pentury, D. Anakotta in 2017 with the title "Rainfall Forecasting in Ambon City Using the Holt-Winters Exponential Smoothing Method". The aims and objectives of this final project are: This study aims to predict monthly rainfall in Ambon City using the Holt-Winter Exponential Smoothing method. The data used in this study is monthly rainfall data for the period January 2005 – December 2016. The data is the result of observations from the Meteorology Station of the Ambon Meteorology, Climatology and Geophysics Agency(Sinay et al., 2017).

Research conducted by Shania Putri Windiistik in 2019 with the title "Design of IoT-Based Flood Detection Systems (Internet of Thing)". The purpose of this research is to implement a flood detection system to reduce material losses caused by disasters and prevent loss of life as well as to provide water capacity information based on IoT (Internet of Thing). This system helps residents to find out whether the detected water has the potential to flood or not. That way, citizens can use the system anywhere and anytime using a smartphone(Windiastik et al., 2019).

Research conducted Moh. Taufik and Iw. Rahman in 2020 with the title "Mapping Of Flood Prone Areas (Case Study: Pacitan Flood)" This Android-based information system application for mapping potential disasters at BPBD was built using the PHP and MySql programming languages for web server admin applications while the android application uses Android studio. The Android-based BPBD mapping information system application for disaster-prone potential can make it easier for users to obtain information and report disasters around them to the BPBD (Taufik & Rahman, 2020).

METHOD

The Single Exponential Smoothing method is a procedure for continuous improvement in forecasting of the latest observation objects. SES actually is a unique type of Moving Average (MA) that uses the exponential function in forming the weighting factors. This forecasting method focuses on exponentially decreasing priority on older observable objects (Hansun & Kristanda, 2019). In exponential smoothing or Single Exponential Smoothing there are one or more smoothing parameters that are specified explicitly, and these results determine the weight assigned to the observed value (Anjani et al., 2020).

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$$Ft + 1 = aXt + (1 - a)Ft \qquad (1)$$

t = current period
α = smoothing constant
Xt = The true value of X
Ft = forecasting in period t
Ft+1 = forecast for the coming period.

RESULT

the results of the research that has been carried out are in accordance with the system development model used, namely the waterfall. In the Waterfall model, there are 5 stages that will be carried out sequentially, namely Requirement Definition, System and Software Design, Implementation and Unit Testing, Integration and System Testing, and Operation and Maintenance(Pascapraharastyan et al., 2014).

Requirement Definition

Requirements Definition is the initial process in designing a system. This is intended to find out what are the problems with the old system or are currently ongoing, as a basis for researchers in analyzing the needs for the proposed new system. On the old system in the process of predicting floods using rainfall data still using manual calculations then the results are in the form of tables and figures, which are not easy for the public to understand. but in the new system that will be created in the process of predicting flood disasters using rainfall data from years back to find out the results that will occur in the coming year. By inputting past data and the system will provide predictive results automatically.

System requirements are divided into two types, namely functional requirements and non-functional requirements. Functional requirements are types of requirements that contain any processes carried out by the system (Al Hanif, 2011).

Table 1.
Functional Requirements

No	***Admin***
1	Admin can display, enter, change, and delete Alternative data.
2	Admin can manage his own profile such as changing password and editing his profile data.
3	Admin can display Calculation Results, as well as print results report data.

Non-functional requirements are divided into two, namely software requirements and hardware requirements.

Table 2.
Software Requirements

No	Software	
1	Operating System	Windows 8/10
2	Web Browser :	FireFox Chorme Microsoft Edge
3	Local Server:	Xampp

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Table 3.
Hardware Requirements

No	Tools	Detail
1	*Input*	*-Keyboard* *-Mouse*
2	*Process*	-Intel Core i3 -RAM (2 GB DDR3)
3	*Output*	*Monitors*
4	*Storage*	*Hard Disk (1 TB)*

The single exponential smoothing method for data that is stationary and does not show a pattern or trend, and can be used to forecast data for future periods.

$$F_{t+1} = F_t + \left(\frac{X_t}{N} - \frac{X_{t-N}}{N}\right) \qquad (2)$$

Ft = Forecasting value at time to-t
Xt = Actual data at time to-t
N = Total data

Data retrieval is carried out to determine the data to be retrieved, so first make a choice of the month for which the results will be determined.

Table 4.
Kulawi Rainfall Data

Year	Month											
	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sep	Okt	Nov	Des
2011	183	97	140	279	337	54	75	175	209	140	283	136
2012	87	161	86	266	179	253	168	234	144	162	414	124
2013	49	483	273	623	326	302	351	240	229	238	368	279
2014	106	60	169	226	424	334	253	219	151	178	380	332
2015	98	312	217	465	274	171	28	16	123	119	400	186
2016	351,5	597,5	552,4	531,5	187	338	313	256	390	290	262,5	82,5
2017	128	212	233,5	232	533	262	155	171	97	317	310	58,5
2018	181	34	357	264	287	187	171	418,5	219,5	242	392	287
2019	161	406	192,7	375	233	138,5	325,5	397,5	74,5	51,2	175,4	239,5
2020	97	294	366,5	428	271,5	201,6	133	110	211	253,5	151	39

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Table 5.
Rainfall Data in January

Year	January
2011	183
2012	87
2013	49
2014	106
2015	98
2016	351,5
2017	128
2018	181
2019	161
2020	97

Determine the Forecast Value in January by determining the data according to the single exponential formula, then determining other factors such as error, absolute, and squared so as to get the MAD Value

Table 6.
Predict Using α = 0.8

Year	January	Forceast	Error	Absolute	Squared
2011	183	183	0	0	0
2012	87	183	-96	96	9216
2013	49	106,2	-57,2	57,2	3271,84
2014	106	60,44	45,56	45,56	2075,71
2015	98	96,888	1,112	1,112	1,23654
2016	351,5	97,7776	253,722	253,722	64375,1
2017	128	300,756	-172,76	172,756	29844,5
2018	181	162,551	18,4489	18,4489	340,362
2019	161	177,31	-16,31	16,3102	266,023
2020	97	164,262	-67,262	67,262	4524,18
Total		110,452	-90,684	728,371	113915

Then determine the average value or MAPE, MAD, MSD using the total data results and determine the SE value

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Table 7.
Forecast Results in January 2021

Year	January	Forceast	Error	Absolute	Squared
2011	183	183	0	0	0
2012	87	183	-96	96	9216
2013	49	106,2	-57,2	57,2	3271,84
2014	106	60,44	45,56	45,56	2075,71
2015	98	96,888	1,112	1,112	1,23654
2016	351,5	97,7776	253,722	253,722	64375,1
2017	128	300,756	-172,76	172,756	29844,5
2018	181	162,551	18,4489	18,4489	340,362
2019	161	177,31	-16,31	16,3102	266,023
2020	97	164,262	-67,262	67,262	4524,18
Total		110,452	-90,684	728,371	113915
Averages		11,0452	-9,0684	72,8371	11391,5
			MAPE	MAD	MSD
			SE		119,329

Table 8.
Forecast Results in January to December 2021

Month	***Forceast***	***Error***	***Absolute***	***Squared***	***Result***	***Status***
January	*110.452*	*-90.684*	*728,371*	*113915*	*119.32*	*Alert*
February	*239.892*	*258.08*	*219.25*	*64845.847*	*284,70*	*Alert*
March	*234.029*	*24.771*	*129.127*	26746.701	*182,84*	*Alert*
April	*352.231*	*16.769*	*145.309*	*36824.391*	*214.54*	*Alert*
Mei	*313.849*	*-8.649*	*124.849*	22748.83	*168.62*	*Alert*
June	*189.595*	*34.605*	*98.009*	*16247.21*	*142.50*	*Alert*
July	*169,77*	*274,3*	*1095,84*	*200646.61*	*158,36*	*Alert*
August	*218.261*	*-45.761*	*150.535*	35353.098	*210.21*	*Alert*
September	*184.4*	*78.1*	100.098	*13720.997*	*130.96*	*Alert*
October	*188.906*	*10.194*	*85.926*	*11349.67*	*119.10*	*Alert*
November	328.502	*-113.002*	*156.42*	*37945.083*	*217.78*	*Alert*
December	*183.583*	*-35.883*	96.197	*15684.594*	*140.02*	*Alert*

Software and System Design

System and Software Design is a process used to change the requirements obtained in the previous stage into representations in the form of blueprints. System And Software Design must be able to implement the requirements mentioned in the Requirements Definition stage (Sherrell, 2013). This Use Case diagram shows the interaction process that players can make to the application.

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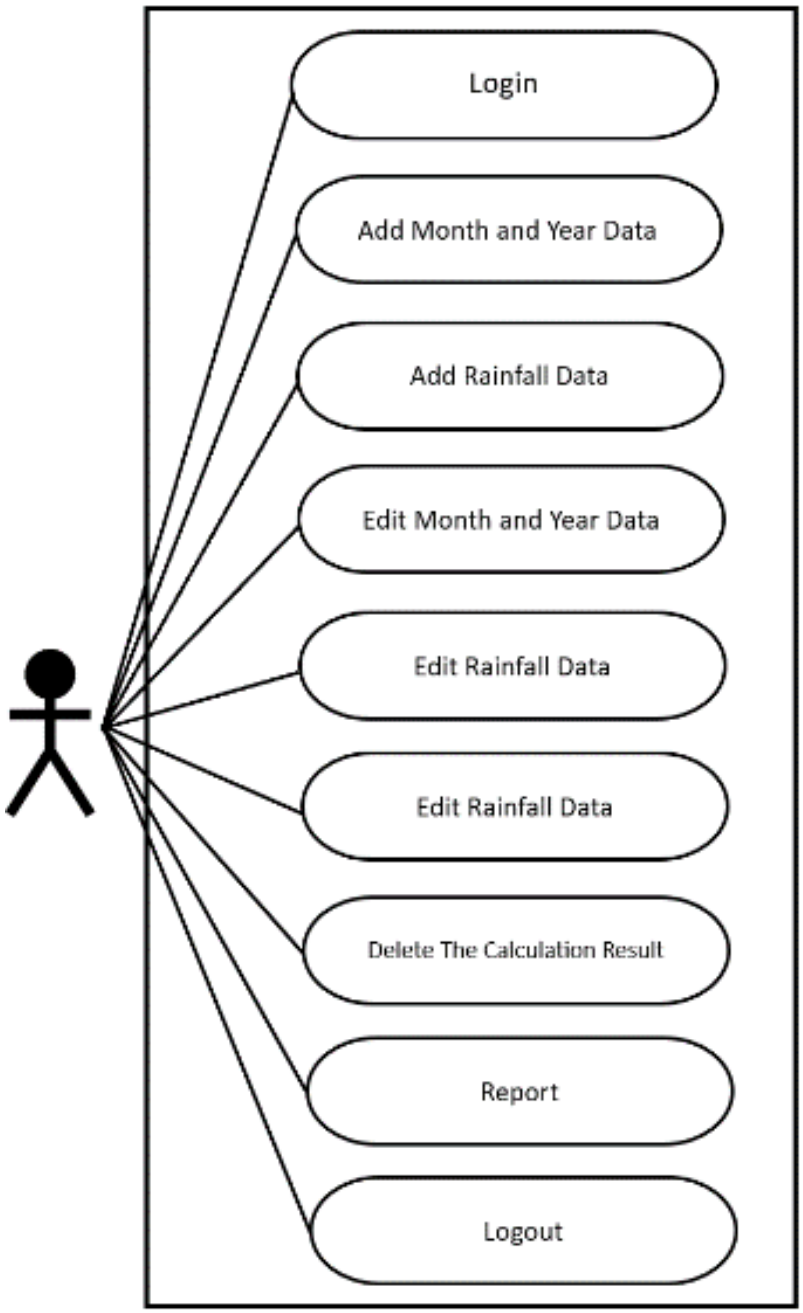

Fig 1. Use Case Diagram

Class diagrams describe the objects that are visible in the system and the relationships between tables in the database. The following is a class diagram of the flood disaster prediction information system.

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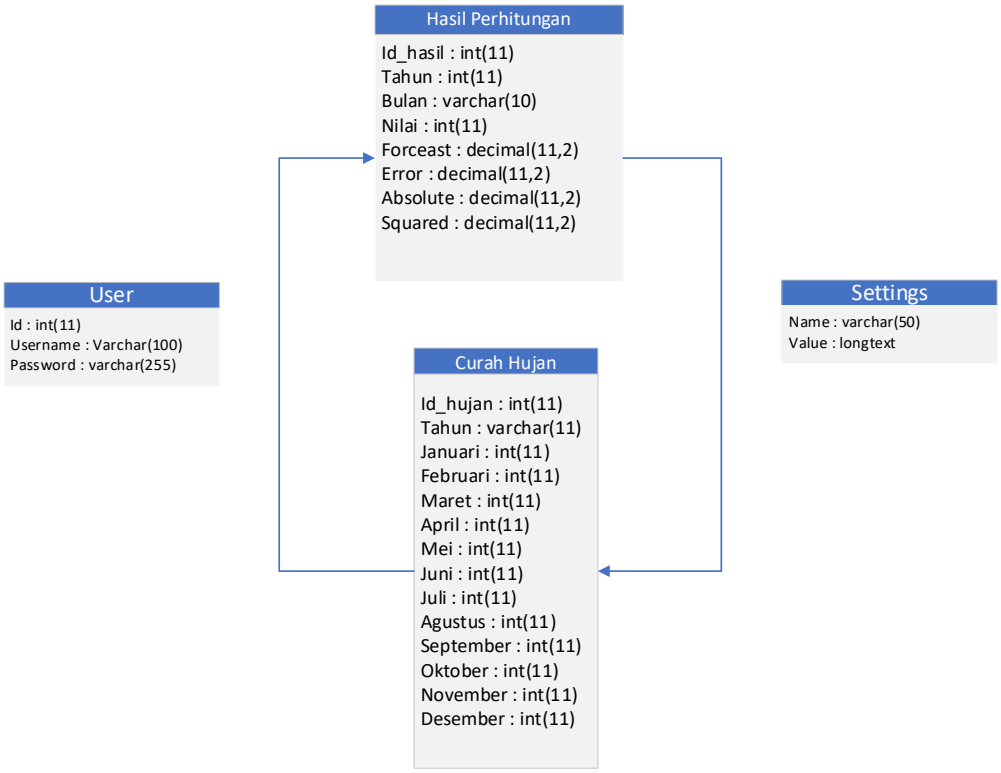

Fig 2. Class Diagram

Activity diagram describes the activity of a decision system. The following is an activity diagram for a flood disaster prediction system.

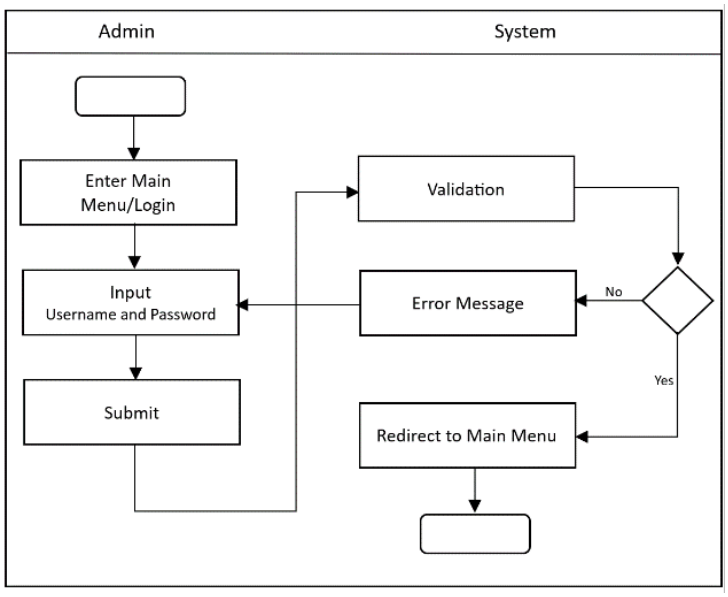

Fig 3. Activity Diagram

The following is the Rainfall Calculation Results page where this page functions as a page for viewing, adding and processing rainfall data to be input. the Report page where this page functions as an output producer from calculating rainfall data.

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Table 9. The Calculation Result

Print No.	Back Year	Month	Rainfall	Forecast	Error	Absolute	Squared
1	2011	January	183	183.00	0.00	0.00	0.00
2	2012	January	87	183.00	-96.00	96.00	9216.00
3	2013	January	49	106.20	-57.20	57.20	3271.84
4	2014	January	106	60.44	45.46	45.56	2075.71
		Total		532.64	-107.64	198.76	14563.55
		Averages		133.16	-26.91	49.69	3640.8875
					MAPE	MAD	MSD
					SE		42.66665828645

Integrations and System Testing

Integration And System Testing is carried out to ensure that the elements or components of the system are functioning as expected. In this study, the testing method used is Black Box Testing. The test point will be worth 1 (one) if the conclusion of the test scenario is in accordance with the desired expectation(Nurhayati et al., 2021).

Operation and Maintenance

Operation And Maintenance is the final stage of the system development method (Sari et al., 2020). Where the operationalization is designed so that it can be carried out at the Mutiara Palu BMKG Office. Meanwhile, system maintenance is carried out with the help of an online version control application service, namely GitHub. By using online version control, it can help with maintenance or maintenance. Maintenance processes such as updating features, adding features and correcting errors or bugs can be pushed to the GitHub website, then the update can be easily saved to a server computer with the clone command.

DISCUSSIONS

Based on the needs analysis, the design/peat at this stage contains a discussion description of the system development carried out and a discussion of the results of system testing. Where the discussion of development results contains a brief explanation of the development steps according to the system development method used. As well as a discussion of the test results containing an assessment of the feasibility validation of the system that was made in this study. The design and implementation of the Application of the Single Exponential Smoothing Method for flood prediction in Sigi Regency can be concluded that the Application of the Single Exponential Smoothing Method for flood prediction in Sigi Regency has succeeded in becoming solutions to problems in the process of providing flood disaster response information in Sigi district. Based on testing with Blackbox testing and using the Simple Exponential Smoothing (SES) algorithm used it produces 88% (very accurate) on the success rate of the test. It is hoped that the results of implementing this system can help the community.

Discussion of System Development Results

The first stage in the development of the system used in making the Sigi district flood disaster prediction system is the requirement definition. Where at this stage the researcher conducted a search for the needs of the system to find out the nature of the system to be made. At this stage the researcher also describes the flow of the old system and the new system for documentation purposes. Requirements analysis for the system created needs to be explained at this stage in order to prepare the right development environment for the system being built.

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The second stage is system and software design. Where at this stage the requirements that have been obtained in the previous stage are made in the form of a blueprint as in this study the system design includes use cases, class diagrams, and activity diagrams. Database design includes table structure and relationships between tables. Then a mockup design or UI (user interface) sketch is made as an illustration of the UI appearance of the system.

The third stage is implementation and unit testing. At this stage the researcher implements according to the design and blueprint that has been carried out at the system and software design stage through the coding process. The mockup made in the previous stage will be a reference in making the user interface display in this process. In this process the researcher uses bootstrap as a css framework and codeigniter as a php framework.

The fourth stage is integration and system testing. At this stage the researcher tested the system, namely testing the functionality of the system created. System testing used to test this system is blackbox testing where the test scenario is carried out in accordance with the test plan that has been made.

The fifth stage is operation and maintenance. At this stage the system that has been integrated is carried out periodic maintenance so that if the system still has errors or errors that were not found from the previous process, it can be resolved by repairing or updating the system. To facilitate this process, researchers use a development tool that is very useful for the maintenance process, namely git. Git is a version control software that has a push feature to remote online version control providers. The online version control that researchers use is gihub.

Discussion of Test Results

The value on the results of system testing on system testing needs to be made an assessment so that the feasibility of the system created can be measured. In accordance with the categories previously defined, namely 0-25% means less feasible, 26-50% means quite feasible, 51-75% means feasible and 76-100% means very feasible(Arikunto, 2002). The test results for each validator are as follows:

76% - 100% = Very Worth It
51% - 75% = Worth It
26% - 50% = Good
0% - 25% = Not Good

Assessment of software success using blackbox testing can be formulated as follows:

$$\text{Eligibility percentage} = \frac{Number\ of\ Successful\ Test\ Scenarios}{Total\ Number\ of\ Scenarios} x\ 100\%$$

$$\text{test result} = \frac{16}{18} x\ 100\% = 88\%$$

From the results of the 18 blackbox 16 testing scenarios, the conclusions are accepted, so it can be concluded that this test gets a feasibility score of 88% and the feasibility of this system can be categorized as "Very Feasible".

CONCLUSION

Based on needs analysis, design/design and implementation of the Application of the Single Exponential Smoothing Method for flood prediction in Sigi district, it can be concluded that the Application of the Single Exponential Smoothing Method for flood prediction in Sigi district has succeeded in becoming a solution to problems in the process of providing flood disaster response information in Sigi district. Based on testing with Blackbox testing and using the Simple Exponential Smoothing (SES) algorithm used it produces 88% (very accurate) on the success rate of the test. It is hoped that the results of implementing this system can help.

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