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Analysis of Spatial Interpolation Method for Rainfall Mapping of Hydrometeorological Disaster Mitigation Design in Denpasar, Bali

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ABSTRACT

Climate change and rapid urbanization are increasing the intensity and uncertainty of rainfall in urban areas, including Denpasar City. The transition from the dry season to the rainy season is often followed by extreme rainfall that triggers floods, disrupts community activities, damages infrastructure, and significantly hinders economic activities. This condition is exacerbated by massive land conversion and the accumulation of waste that clogs drainage systems, leading to a drastic decrease in surface water holding capacity. Therefore, hydrometeorological disaster mitigation has become an urgent need, which must be supported by accurate and reliable spatial rainfall information to identify vulnerable areas and design more effective flood control strategies. This study evaluates and compares the spatial interpolation methods of Inverse Distance Weighting (IDW), Kriging, and Spline in mapping the distribution of design rainfall in Denpasar City. Data were obtained from six stations over the period 2013–2022 and analyzed based on various return periods, namely 2, 5, 10, 15, 20, 25, and 50 year. To comprehensively assess the performance of interpolation methods, statistical indicators such as Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Squared Error (RMSE), and Coefficient of Determination (R^2) were used. The results show that IDW is most accurate for short return periods, particularly 2 year, with low MAE, MAPE, and RMSE and high R^2. Kriging excels for medium to long return periods (5–50 years), producing stable predictions that closely match the observed data, while Spline tends to have higher errors and low R^2, especially for long return periods. This result confirms that IDW and Kriging are the most reliable and accurate methods for mapping the distribution of design rainfall in Denpasar City.

1. Introduction

The transition from the dry season to the rainy season in Indonesia is marked by increasingly extreme and unpredictable rainfall patterns. The Meteorology, Climatology, and Geophysics Agency (BMKG) reports that heavy to very heavy rains pose a significant threat in several regions, including Bali [1]. One of the most striking events occurred on September 9–10, 2025, when extreme rainfall triggered massive flooding in various areas. According to records from the Bali Provincial Disaster Management Agency (BPBD) [2]. More than 120 flood points were recorded in Bali, with 81 of them in Denpasar City, making it the area with the greatest impact. [3].

The floods that hit Denpasar not only disrupted community activities, but also damaged infrastructure and hampered economic activity. Extreme rainfall intensity was the primary factor causing the floods [4], [5], However, the condition is further exacerbated by massive land conversion and the accumulation of waste that clogs drainage channels, so that the surface water capacity decreases [6] – [8]. This situation emphasizes that high-density cities are highly vulnerable to hydrometeorological disasters [9]. Therefore, mitigation

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measures are urgently needed, and one important initial step is mapping rainfall distribution [10], [11]. Spatial rainfall information is essential for identifying vulnerable areas, designing more effective flood control systems, and allocating mitigation resources appropriately [12] – [14].

Efforts to understand the spatial distribution of rainfall can be done with the help of geographic information systems (GIS) through the interpolation process, with the most commonly used methods being Inverse Distance Weighting (IDW), Kriging, and Spline [15] – [18]. Previous research has applied each method in various locations, such as mapping rainfall distribution with IDW in Kediri Regency [19], Kriging in the Kali Lamong watershed [20], and Spline in Jakarta City [21]. Several studies have compared spatial interpolation methods for rainfall mapping. In areas with a limited number of rainfall stations, such as Pontianak, the IDW method provides more accurate interpolation results. Spline produces a smooth surface through several points, and Kriging requires a strict assumption of spatial homogeneity [16]. A study on the Abab Sub-watershed, Blitar Regency showed that IDW and Spline had high agreement with field data, while Kriging produced larger errors as the return period increased, so IDW was chosen for design rainfall mapping [18]. In the Upper Brantas Sub-DAS, the IDW method showed the highest accuracy, characterized by the smallest RMSE, very good NSE, and a very strong

Correlation Coefficient [17]. Research in North Sumatra shows that the Spline method provides the best performance, with the lowest RMSE and MAE values and smooth interpolation through station points [22]. Based on these findings, a comparative analysis of interpolation methods is important because their effectiveness is highly dependent on the specific conditions of each region. However, research that comparatively assesses interpolation methods in the context of Denpasar City, a densely populated urban area prone to hydrometeorological disasters, remains limited. This study does not only compare interpolation methods, but also integrates rainfall spatial modeling into hydrometeorological disaster mitigation planning in an urban tropical environment, specifically Denpasar City, which has unique rainfall variability and rapid urbanization. In this context, the study evaluates and compares the performance of IDW, Kriging, and Spline methods to determine the most appropriate interpolation approach for the spatial characteristics of Denpasar. Furthermore, this research contributes not only methodologically but also practically by providing a scientific basis for rainfall mapping that can support decision-making in hydrometeorological disaster mitigation, particularly flood risk management in urban areas. The results are expected to serve as a reference for both researchers and policymakers in developing more adaptive and spatially informed mitigation strategies.

2. Methods

This study uses a descriptive quantitative method with a comparative approach to analyze rainfall distribution in Denpasar City, Bali. This approach involves collecting daily rainfall data from rainfall stations in the study area, followed by calculating design rainfall for various return periods. The calculation results are then processed using three spatial interpolation methods, namely Inverse Distance Weighting (IDW), Kriging, and Spline, to produce a rainfall distribution map. The final stage of the study is to conduct a comparative analysis of the three interpolation methods, using observation data from each rainfall station as a validation reference. This analysis aims to evaluate the accuracy, advantages, and limitations of each method, and determine the most appropriate approach based on the climate conditions and spatial characteristics of Denpasar City.

2.1 Research Location

This research was conducted in Denpasar City, Bali Province, as shown in Figure 1. Denpasar City, as the capital of Bali Province, is an urban area with a high population density. Geographically, Denpasar City is located between coordinates 8°35'31" to 8°44'49" South Latitude and 115°00'23" to 115°16'27" East Longitude. Denpasar City is often affected by flooding due to extreme rainfall and limited urban drainage systems [23]. This condition makes the city relevant as a research location for mapping the distribution of design rainfall, to support more effective flood mitigation planning.

2.2 Research Data

This study uses maximum daily rainfall data from six stations in Denpasar City: Buagan Station, Penatih Station, Ubung Station, Sumerta Station, Sanglah Station, and Suwung Station. The data covers the period 2013–2022 and was obtained from the Bali Penida River Basin Center and the Denpasar Region III Meteorology, Climatology, and Geophysics Office. In addition to rainfall data, this study also uses spatial data, in the form of an administrative map of Denpasar City and a map of the distribution of rainfall stations, obtained from the Tanah Air Indonesia Web portal. Figure 2 shows the distribution of rainfall stations in Denpasar City.

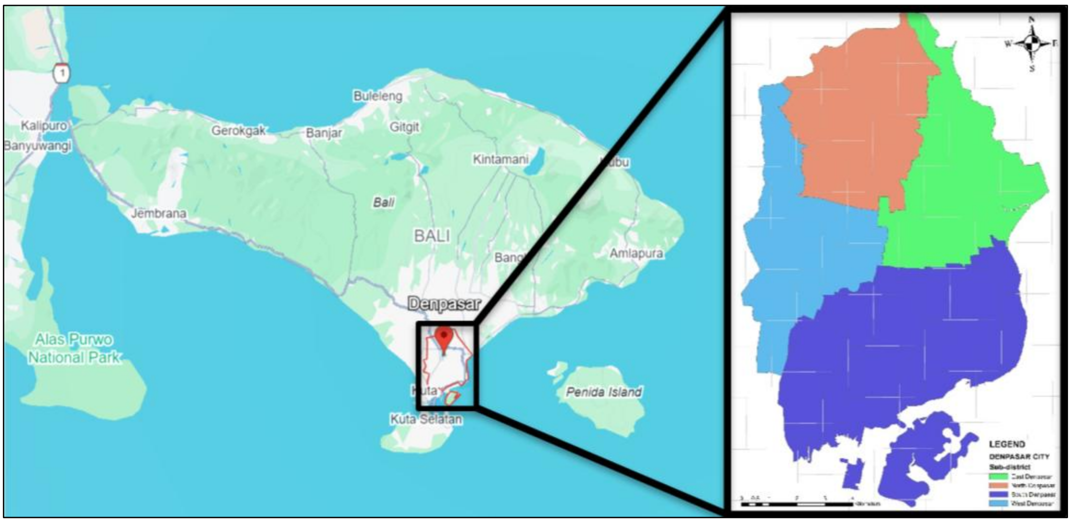

Figure 1. Research Location

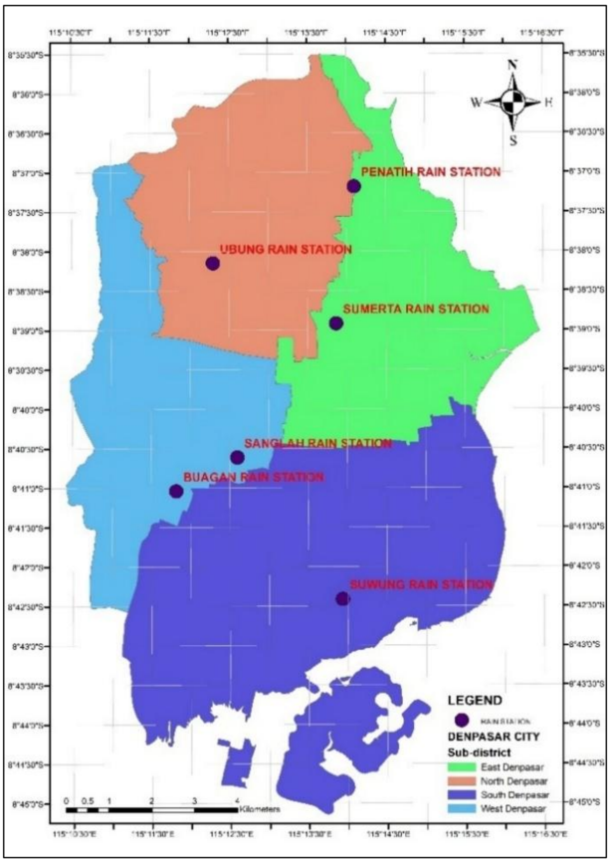

Figure 2. Distribution of rainfall stations in Denpasar City

2.3 Data Consistency Test

To obtain valid rainfall data, a data consistency test is required to ensure that the data used comes from a uniform population and is not influenced by recording errors or other non-climatic factors [24], [25]. The method used in this study is Rescaled Adjusted Partial Sums (RAPS). This method is based on testing the cumulative deviation of data against the average value, which is then normalized by the standard deviation to obtain a measure of data consistency [26], [27]. The RAPS calculation formula is presented in Equations (1) to (4).

$$So^* = 0 \tag{1}$$

$$Sk^* = \sum_{i=1}^{k}(Yi - \overline{Y}) \text{ , with } k = 1, 2, 3, n \tag{2}$$

$$Sk^{**} = \frac{Sk^*}{Dy} \tag{3}$$

$$Dy^2 = \sum_{i=1}^{n}\frac{|Sk^*|^2}{n} \tag{4}$$

Where *So** is the initial deviation value, *Sk** is the cumulative deviation, *Sk*** is the data consistency value, *Yi* is the i-th rainfall data, $\overline{Y}$ is the average rainfall data, *Dy* is the standard deviation, and n is the number of data.

For the consistency test, Equations (5) and (6) are used.

$$Q = \text{Maks } |Sk^{**}| \text{ , with } 0 \le k \le n \tag{5}$$

$$R = \text{Maks } |Sk^{**}| - \text{Min } |Sk^{**}| \tag{6}$$

With the provision that for a data set of 10 and a confidence level of 90%, the *Q/n^0.5* value must not exceed 1.05. Meanwhile, the *R/n^0.5* value must not exceed 1.21 [27].

2.4 Design Rainfall Analysis

Design rainfall is defined as the ideal rainfall intensity determined statistically based on a certain return period, so that it can represent extreme rainfall conditions that could potentially occur in the future [28], [29]. To analyze design rainfall, there are several frequency distribution methods commonly used in hydrology, namely the Normal Distribution, Log Normal Distribution, Gumbel Distribution, and Log Pearson Type III Distribution. In this study, the frequency distribution analysis used is the Log Pearson III method, which is further explained through the following steps [30]:

a. Convert the data to logarithmic form according to Equation (7).

$$X = logX \quad (7)$$

b. Calculate the logarithmic mean using Equation (8).

$$log\bar{X} = \frac{\sum_{i=1}^{n} log\, Xi}{n} \quad (8)$$

c. Determine the standard deviation according to Equation (9).

$$S = \frac{\sqrt{\sum_{i=1}^{n} (Log\, Xi - X)^{\bar{2}}}}{(n-1)} \quad (9)$$

d. Calculate the skewness coefficient using Equation (10).

$$Cs = \frac{n.\sum_{i=1}^{n} (Log\, Xi - X)^3}{(n-1)(n-2)S^3} \quad (10)$$

Where in the calculation, X_T indicates rainfall for the period *"T"* years, n is the number of years of observation, S is the standard deviation, $\bar{X}$ is the average rainfall, Xi is the maximum rainfall each year, and Cs is the skewness coefficient.

2.5 Spatial Interpolation of Rainfall Distribution

Spatial interpolation is a technique for estimating rainfall values at points where measurements have not yet been taken, by utilizing information from surrounding observation points [31]. This method allows for more comprehensive and accurate mapping of rainfall distribution, thus supporting hydrological analysis, drainage planning, and water resource management. Rainfall estimates in ungauged areas are generally performed using several interpolation methods, including Inverse Distance Weighting (IDW), Kriging, and Spline [15], [22], [32].

Inverse Distance Weighting (IDW) is a spatial interpolation method used to estimate values at a location by utilizing data from surrounding observation points [16], [33]. In this method, the influence of each observation point decreases as the distance to the target location increases. IDW is capable of producing quite detailed interpolation surfaces, especially when the observation points are evenly distributed. However, this method has limitations: the interpolation value cannot exceed the maximum value or fall below the minimum value of the observation data [20]. The IDW method is calculated based on Equations (11) and (12).

$$F(z_x) = \sum_{i=1}^{n} w_i . z_i \quad (11)$$

$$w_i(x) = \frac{\left[\frac{1}{d}\right]^p}{\sum_{i=1}^{n}\left[\frac{1}{d}\right]^p} \quad (12)$$

With n being the number of observation points, i and j being the number of observation points, w_i being the weighting factor, d being the distance between observation points and p being the power of the weight.

Kriging is a spatial interpolation method that estimates values at a location by utilizing measured values in the surrounding area through weighting [34], [35]. The determination of weights is based on the distance between the observation point and the predicted location, and takes into account the spatial structure in the form of autocorrelation between points [22]. The general Ordinary Kriging model is stated in Equation (13). Next, assuming a constant mean value and random errors that have spatial dependence, the predictor is obtained through a weighted summation of the measured data, as shown in Equation (14).

$$z(s) = m + e(s) \quad (13)$$

$$\hat{z}(s_0) = \sum_{i=1}^{n} \lambda_i * z(s_i) \quad (14)$$

Where $z(s_i)$ is the measured value at the *i-th* location, λi is the unknown weight for the measured value at the *i-th* location, s_0 is the predicted location, and n is the number of measured values.

The Spline method is an interpolation technique that aims to produce a smooth surface by minimizing the curvature of the curve, so that the estimated values pass through the sample points accurately. This method is able to predict extreme values, both minimum and maximum, by considering the effects of data distribution, and still produces a precise surface estimate even with limited available data [35]–[37]. The basic principle of interpolation using the Spline method is shown in Equation (15).

$$S(x,y) = T(x,y) + \sum_{i=1}^{n} \lambda_i . R(r)_i \quad (15)$$

Where n represents the number of observation points, λi are the coefficients obtained from the linear system, and ri is the distance between two points *(x,y)*. The notations $T(x,y)$ and r have different interpretations depending on the selection method used.

2.6 Mapping of Design Rainfall Distribution

Mapping of the design rainfall distribution was carried out by applying the IDW, Kriging, and Spline spatial interpolation methods using a Geographic Information System through the ArcGIS application, with work procedures that include the following stages:

a. Open a new worksheet in ArcGIS.
b. Enter 10-year average daily maximum rainfall data for the entire Denpasar City area
c. Add an administrative map and basemap layer to the application.
d. Conduct spatial analysis using IDW, Kriging, and Spline methods.
e. Set data classification and map symbology display.
f. Add labels to the attribute table.
g. Create a map layout for presentation.
h. Export the analyzed map as a JPEG image.

2.7 Evaluation of Rainfall Interpolation Results

Interpolation results are evaluated to assess the accuracy and reliability of the design rainfall distribution estimates. This process involves comparing rainfall values estimated by the IDW, Kriging, and Spline methods with actual observation data at each rainfall station [22]. Some statistical indicators commonly used in model performance evaluation include Mean Absolute Error (*MAE*), Mean Absolute Percentage Error (*MAPE*), Root Mean Square Error (*RMSE*) and Coefficient of Determination (R^2) [38], [39], with calculations referring to Equations (16) to Equation (19).

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|Xi.Yi| \quad (16)$$

$$\mathrm{MARE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{Yi.Xi}{Yi}\right| \quad (17)$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Xi.Yi)^2} \quad (18)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Xi.Yi)^2}{\sum_{i=1}^{n}(\bar{Y}.Yi)^2} \quad (19)$$

Where *Xi* is the observation data, *Yi* is the estimation/interpolation result, $\bar{X}$ is the average of all observation data, and n is the total number of data points or observations. The MAE, RMSE, and MAPE values can be interpreted based on the ranges shown in Table 1, while the R^2 value can be interpreted according to the ranges in Table 2, as an indicator of the model's accuracy in representing real data [40].

Table 1. Interpretation of MAE, MAPE, and RMSE values

Range of values	Interpretation
< 10	High level of prediction
10 – 20	Acceptable prediction
20 – 50	Tolerable prediction
> 50	Unacceptable prediction

Table 2. Interpretation of R^2 values

Range of values	Interpretation
0	No correlation
0 < R2 ≤ 0.25	Very weak correlation
0.25 < R2 ≤ 0.50	Fair correlation
0.50 < R2 ≤ 0.75	Strong correlation
0.75 < R2 ≤ 0.99	Very strong correlation
1.00	Perfect correlation

3. Results and Discussion

3.1 Rescaled Adjusted Partial Sums (RAPS) Test

The results of the RAPS test on rainfall data from six stations in Denpasar City during the 2013–2022 period are presented in Table 3. The statistical values show that the data is relatively consistent and there is no significant trend, so it can be used for further analysis.

Table 3. RAPS Test Results

Station name	RAPS Test					
	Q_{count}	Q_{table}	Information	R_{count}	R_{table}	Information
Buagan Station	0.41	1.05	Consistent	1.13	1.21	Consistent
Penatih Station	0.58	1.05	Consistent	1.11	1.21	Consistent
Ubung Station	0.56	1.05	Consistent	0.88	1.21	Consistent
Sumerta Station	0.53	1.05	Consistent	0.95	1.21	Consistent
Sanglah Station	0.68	1.05	Consistent	0.12	1.21	Consistent
Suwung Station	0.34	1.05	Consistent	0.32	1.21	Consistent

3.2 Design Rainfall

Design rainfall was obtained from processing daily rainfall data for the 2013–2022 period at six rainfall stations in Denpasar City using the Log Pearson Type III method. This method is used to calculate extreme rainfall at several return periods: 2, 5, 10, 15, 20, 25, and 50 years. The results of the design rainfall calculations for each return period are presented in Table 4.

3.3 Design Rain Distribution Mapping

Based on the design rainfall values at each station for each return period, an interpolation analysis was performed to map the distribution of rainfall in the Denpasar City area. This analysis was conducted to accurately depict spatial variations in rainfall and provide information that can be used as a basis for hydrological planning and flood mitigation strategies. The map presentation focuses on the 2-year return period, as shown in Figure 3, Figure 4, and Figure 5, which show the results of interpolation using the IDW, Kriging, and Spline methods, respectively.

Table 4. Design rainfall for 2-50 yr return period in Denpasar City

Station name	Design rainfall (mm)						
	2-yr	5-yr	10-yr	15-yr	20-yr	25-yr	50-yr
Buagan	129	185	228	244	262	281	337
Penatih	119	158	184	194	205	217	240
Ubung	118	147	1601	166	170	175	184
Sumerta	133	168	187	194	200	207	220
Sanglah	118	154	154	184	192	201	219
Suwung	90	104	112	115	118	121	126

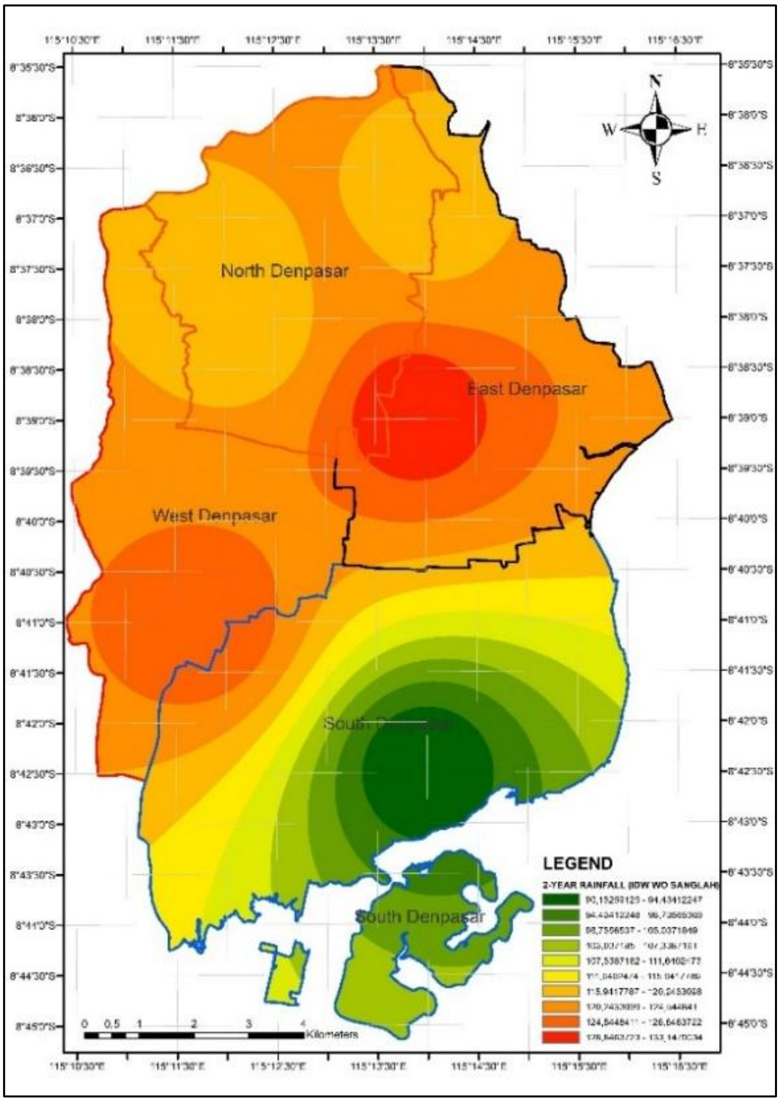

Figure 3. Map of rainfall distribution with a 2-year return period in Denpasar City using the IDW method

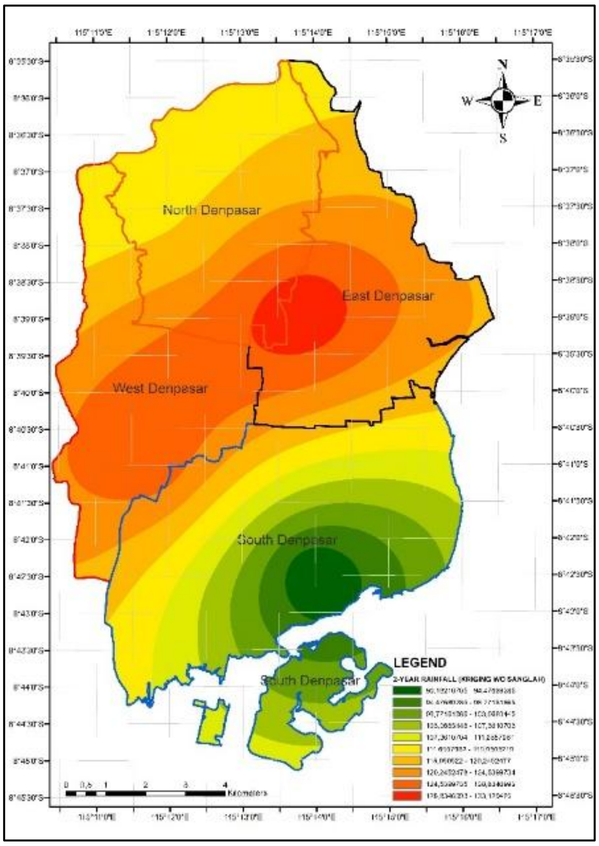

Figure 4. Map of rainfall distribution with a 2-year return period in Denpasar City using the Kriging method

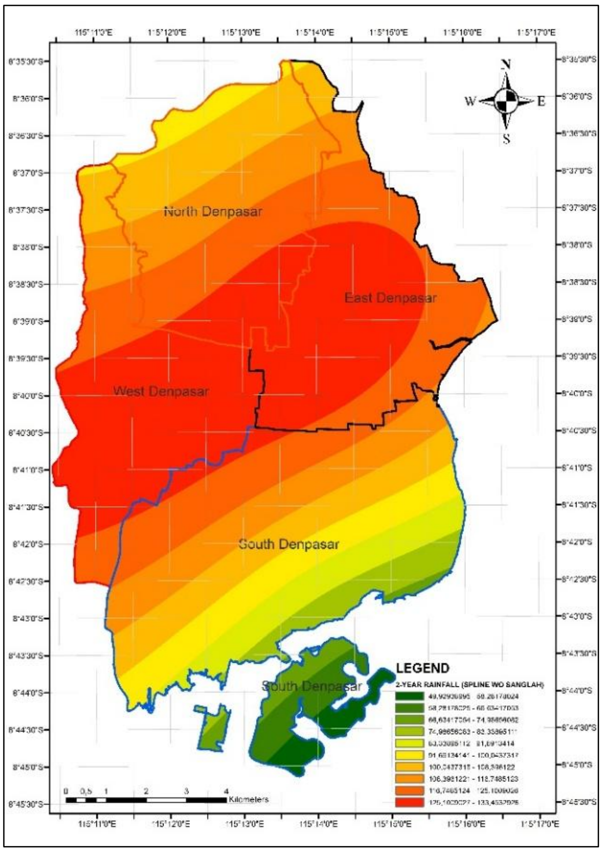

Figure 5. Map of rainfall distribution with a 2-year return period in Denpasar City using the Spline method

Table 5. Mean Absolute Error (MAE) value of the design rainfall interpolation results

Method	Return Period						
	2 yr	5 yr	10 yr	15 yr	20 yr	25 yr	50 yr
IDW	12.888	23.736	39.262	39.634	44.797	50.082	66.660
Kriging	13.283	23.478	37.740	38.356	42.857	48.613	59.146
Spline	22.433	37.707	55.679	57.297	62.753	68.628	88.806

3.1 Performance Comparison of Design Rainfall Interpolation Methods

To evaluate the performance differences between interpolation methods in mapping the design rainfall distribution, a comparative analysis was conducted based on several relevant statistical indicators, namely Mean Absolute Error (*MAE*), Mean Absolute Percentage Error (*MAPE*), Root Mean Squared Error (*RMSE*), and R^2. This analysis aims to assess how well each method is able to represent the observation data and to determine the most effective method in describing the spatial variation of rainfall in the Denpasar City area. The evaluation results of each indicator are presented in Table 5 for MAE, Table 6 for MAPE, Table 7 for RMSE, and Table 8 for R^2.

Based on Table 5, the Mean Absolute Error (*MAE*) value shows that Kriging has the lowest average error at most return periods, ranging from 13.283 mm at the 2 year return period to 59.146 mm at the 50 year return period. The IDW MAE value is slightly above Kriging, ranging from 12.888 mm at 2 year to 66.660 mm at 50 year. Meanwhile, Spline shows the highest MAE value, ranging from 22.433 mm at 2 year to 88.806 mm at 50 year, indicating a relatively less accurate estimate compared to the other two methods.

Table 6. Mean Absolute Percentage Error (*MAPE*) values from design rainfall interpolation results

Method	Return Period						
	2 yr	5 yr	10 yr	15 yr	20 yr	25 yr	50 yr
IDW	11.944%	17.797%	26.113%	24.983%	27.035%	28.938%	34.636%
Kriging	12.195%	17.379%	24.754%	23.822%	25.516%	27.603%	30.386%
Spline	19.840%	26.979%	35.834%	35.476%	37.529%	39.661%	46.811%

Table 7. Root Mean Square Error (*RMSE*) value of the design rainfall interpolation results

Method	Return Period						
	2 yr	5 yr	10 yr	15 yr	20 yr	25 yr	50 yr
IDW	16.364	30.726	46.783	48.685	54.820	61.117	81.906
Kriging	17.231	30.591	45.364	47.531	53.157	60.347	79.042
Spline	23.601	40.744	59.820	64.567	71.571	79.384	102.224

Table 8. Coefficient of Determination (R^2) values for the interpolated rainfall data

Method	Return Period						
	2 yr	5 yr	2 yr	15 yr	2 yr	25 yr	2 yr
IDW	0.937	0.915	0.885	0.873	0.864	0.858	0.833
Kriging	0.887	0.905	0.896	0.886	0.883	0.861	0.929
Spline	0.030	0.336	0.263	0.238	0.239	0.231	0.205

Analysis of the Mean Absolute Percentage Error (*MAPE*) values in Table 6 shows a similar trend to MAE. Kriging produces the smallest percentage error, ranging from 12.195% at 2 yr return periods to 30.386% at 50 yr. IDW has a slightly lower MAPE value at short return periods (11.944% for 2 yr) but increases to 34.636% at 50 yr. Spline has the highest MAPE, ranging from 19.840% to 46.811%, confirming that this method is less precise.

Table 7 shows the Root Mean Squared Error (*RMSE*) values, where Kriging and IDW have lower RMSE than Spline. Kriging has an RMSE of 17.231 mm at a 2yr return period and 79.042 mm at 50 yr, while IDW is slightly higher, ranging from 16.364 mm to 81.906 mm. Spline shows the highest RMSE, ranging from 23.601 mm at 2 yr to 102.224 mm at 50 yr, indicating a larger deviation from the observed values.

Based on Table 8, the Coefficient of Determination (R^2) values show a strong correlation between the interpolation results and the observed data for IDW (0.937–0.833) and Kriging (0.887–0.929) across all return periods. In contrast, Spline has low R^2 values, ranging from 0.030 to 0.205, especially at short return periods, indicating poor spatial representation capabilities.
The evaluation of the four statistical indicators (*MAE*, *MAPE*, *RMSE*, and R^2) shows varying performance patterns for the interpolation methods. IDW provides more accurate estimates at short return periods, particularly 2 yr, with relatively low error values and a high coefficient of determination. Kriging demonstrates superiority at medium to long return periods (5–50 yr), producing stable predictions that closely match the observed data. Spline tends to have higher error and a low R^2, especially at long return periods. Overall, this evaluation confirms that the effectiveness of the interpolation method is highly dependent on the return period and data characteristics at each station, so the choice of method must be adjusted to the needs of the hydrological analysis.

To further strengthen the interpretation of these results, a comparison with previous studies is necessary. Several studies have reported varying performance of interpolation methods depending on spatial characteristics and data distribution. For instance, research conducted in the Upper Brantas Sub-watershed showed that the IDW method produced the highest accuracy, particularly due to its ability to capture localized rainfall variability in areas with relatively uniform station distribution [17]. This finding is consistent with the results of this study, where IDW demonstrates superior performance at short return periods, indicating its effectiveness in representing local rainfall patterns in urban environments.

On the other hand, studies in the Abab Sub-watershed indicated that Kriging tends to produce larger errors under certain conditions, particularly when spatial homogeneity assumptions are not fully met [18]. However, in this study, Kriging shows better performance at medium to long return periods. This difference may be influenced by the spatial autocorrelation structure of rainfall in Denpasar City, where urban morphology, land use change, and drainage patterns create more structured spatial relationships that can be better captured by geostatistical methods such as Kriging.
Furthermore, research conducted in North Sumatra found

that the Spline method can provide good interpolation results under specific conditions, especially when data distribution is smooth and continuous [22]. In contrast, the results of this study show that Spline performs poorly, particularly at longer return periods, as indicated by higher error values and lower R^2. This discrepancy suggests that Spline may be less suitable for areas with high rainfall variability and complex spatial patterns, such as Denpasar, where rapid urbanization significantly influences hydrological processes.

These differences highlight that the performance of interpolation methods is not universal but strongly influenced by regional characteristics, including station density, spatial variability of rainfall, and urban landscape complexity. Therefore, the selection of interpolation methods should not be generalized, but must be adapted to local conditions. In the case of Denpasar City, the combination of IDW for shortterm analysis and Kriging for longterm estimation provides a more reliable approach for supporting hydrometeorological disaster mitigation planning, particularly in urban flood risk assessment. This finding reinforces the importance of integrating spatial analysis with urban hydrological characteristics to improve the accuracy of rainfall-based disaster mitigation strategies.

4. Conclusion

From the overall analysis, it can be concluded that IDW and Kriging are the most reliable interpolation methods to represent the design rainfall distribution in Denpasar City, with IDW superior at short return periods and Kriging superior at medium to long return periods. Spline does not provide optimal results, especially at long return periods. This finding emphasizes the importance of selecting the right interpolation method to support hydrological planning and mitigation strategies for hydro-meteorological disasters such as floods. In practical terms, the use of IDW can support short-term flood risk identification, particularly for early warning systems and rapid response planning, while Kriging is more suitable for long-term flood mitigation planning, including drainage system design, retention basin development, and urban water management strategies. Therefore, accurate rainfall mapping generated from appropriate interpolation methods can assist local governments and planners in identifying flood-prone areas, optimizing infrastructure planning, and improving the effectiveness of flood mitigation measures in urban environments such as Denpasar City.

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