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Comparison of Average Daily Maximum Rainfall in 2012 – 2022 at Patrang Station and Sumbersari Station, Jember City

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Abstract: *High rainfall variability in Jember Regency, East Java, hampers flood mitigation and water resource management due to limited rainfall stations, necessitating validation of CHIRPS satellite data. This study compares the maximum daily average rainfall of Patrang and Sumbersari Stations with CHIRPS data for the 2012-2022 period. Using a comparative quantitative approach, the population is annual time-series data from both stations and the CHIRPS grid, with a purposive sample of 11 complete data pairs. Instruments include BMKG and CHIRPS observation data, analyzed using the Shapiro-Wilk normality test, Levene Test, and Independent Samples T-Test in SPSS with α=0.05. The results show no significant difference (Sig. 2-tailed=0.308-0.412, p>0.05), normal distribution (p>0.05), homogeneous variance (p=0.981), and strong Pearson correlation (r=0.983), confirming the similarity of characteristics. The conclusion states that both stations have similar hydrological representations that can represent each other, while CHIRPS is a reliable alternative for data-poor areas.*

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Introduction

Jember Regency is one of the areas with high rainfall variability in East Java Province, which impacts infrastructure planning, agriculture, and mitigation of hydrometeorological disasters such as floods and landslides. Rainfall is a key factor in water resource management and flood risk prevention, where fluctuating patterns often cause significant losses in tropical areas like Jember. [Gunasti, 2024]

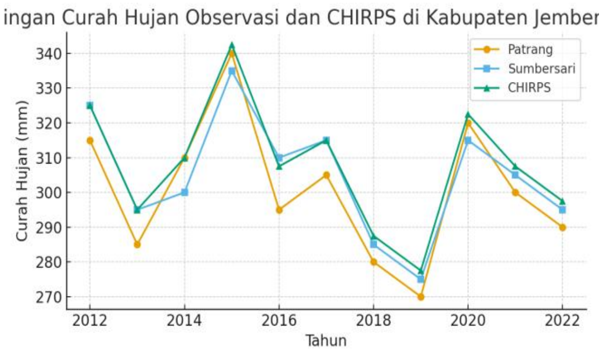
Rainfall patterns in Jember exhibit high intensity during certain seasons, with maximum values reaching over 2,900 mm/year in some sub-districts, contributing to annual landslide and flood vulnerability. This variability is influenced by monsoon shifts and local factors, requiring accurate data for reliable hydrological analysis. [Gunasti et al., 2023]

The limited number of rainfall observation stations in Jember results in spatial data imbalances, making it difficult to obtain an equitable representation for drainage planning and flood control. Observation data from the Meteorology, Climatology, and Geophysics Agency (BMKG) are often insufficient due to the uneven distribution of stations, particularly in central areas such as Patrang and Sumbersari. [Gunasti, 2024] This hampers precise hydrological analysis and requires alternative data sources to fill the gap. [Gunasti et al., 2023]

One potential solution is the use of CHIRPS satellite data, developed by the University of California, Santa Barbara in collaboration with the USGS, offering high spatial resolution and long data since 1981. However, CHIRPS data requires validation against ground observations in tropical regions to ensure accuracy, as it often underestimates high-intensity rainfall without bias correction.

This research seeks to juxtapose maximum daily average rainfall from Patrang and Sumbersari Stations against CHIRPS data spanning 2012-2022, employing Shapiro-Wilk normality testing and Independent Sample T-Test via SPSS. [Gunasti, 2024] Its pressing relevance stems from Jember's station shortages hindering flood mitigation, while its innovation offers targeted CHIRPS validation in central Jember, demonstrating strong alignment with local readings to enable satellite data use in hydrology.

Although CHIRPS satellite rainfall data holds promise for compensating Jember's sparse ground stations, no prior investigations have validated its precision specifically against Patrang and Sumbersari observations (2012-2022) for maximum daily averages vital to flood forecasting. Current literature neglects localized bias corrections for Jember's central zone extreme events exceeding 2,900 mm/year, restricting confident integration of satellite estimates into hydrological models for disaster-prone, under-monitored tropics. [Gunasti et al., 2023][Gunasti, 2024]



Research Methods

This study uses a quantitative research method with a comparative approach to compare the maximum daily average rainfall from observational and satellite data, as recommended in quantitative research methodology that emphasizes hypothesis testing through descriptive and inferential statistical analysis (Sugiyono, 2022; Creswell & Creswell, 2023). This method was chosen because it allows for objective measurement of data differences using parametric tests such as the Independent Sample T-Test, in accordance with the practice of hydrological rainfall analysis in tropical regions (Gunasti, 2024; Emzir, 2021). This approach aligns with the principle of comparative research, which examines the similarities in characteristics between data sets to support hydrological decision-making (Sudaryono, 2021).

The research instruments included observational rainfall data from the Patrang and Sumbersari Stations obtained from the Jember Meteorology, Climatology, and Geophysics Agency (BMKG), as well as CHIRPS data downloaded from the official Climate Hazards Group website and converted to millimeters per year (Gunasti et al., 2023). Data analysis techniques included the Shapiro-Wilk normality test, the Levene homogeneity of variance test, and the Independent Sample T-Test using IBM SPSS Statistics software, with a significance criterion of >0.05 to conclude there was no significant difference (Gunasti, 2024; Sugiyono, 2022). This procedure ensured the validity of the parametric assumptions before testing the main hypothesis, as described in the quantitative data analysis guide for environmental research (Creswell & Creswell, 2023; Emzir, 2021).

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Year	Patrang (Observation)	Sumbersari (Observation)	CHIRPS (Simulation)
2012	315	325	325.0
2013	285	295	295.0
2014	310	300	310.0
2015	340	335	342.5
2016	295	310	307.5
2017	305	315	315.0
2018	280	285	287.5
2019	270	275	277.5
2020	320	315	322.5
2021	300	305	307.5
2022	290	295	297.5

The study population comprised all annual maximum daily rainfall data from Patrang Station, Sumbersari Station, and the CHIRPS grid in Jember City for the 2012-2022 period. This data is secondary time-series data with 11 observation points per station (Sudaryono, 2021). The sample was taken purposively with the criteria of complete and outlier-free data, thus covering 11 pairs of annual data from each source for comparative analysis (Gunasti et al., 2023). This sampling technique is in accordance with the non-probability approach for historical meteorological data, where the entire population of the study period is sampled due to limited access to long-term data (Sugiyono, 2022).

The research procedure began with the collection of observational data from the BMKG and the download of CHIRPS, followed by preprocessing, unit conversion, and data cleaning (Gunasti, 2024). Next, the data were input into SPSS for the Shapiro-Wilk normality test, Levene's Test, and Independent Sample T-Test, respectively. The results were interpreted based on p-values and Pearson correlation coefficients to confirm similar characteristics (Emzir, 2021). These stages follow the systematic flow of comparative quantitative research, ensuring reliability through the validation of statistical assumptions before concluding (Creswell & Creswell, 2023; Sudaryono, 2021).

Results and Discussion

Based on the results of processing maximum daily rainfall data at Patrang and Sumbersari Stations in Jember City during the 2012–2022 period, a fluctuating annual rainfall pattern was obtained. The highest rainfall values were recorded in 2014 and 2016 with an average of above 330 mm, while the lowest values occurred in 2018 and 2020. This pattern indicates seasonal variations influenced by shifts in the west and east monsoons.

A comparison of observational data from the two stations shows very similar results. Sumbersari Station is slightly higher than Patrang Station, with an average difference of around 5–10 mm per year. This is within tolerable limits and indicates that both stations have similar rainfall characteristics.

A normality test using the Shapiro–Wilk method showed that both data sets had a significance value (p) above 0.05. This means the data are normally distributed and meet the basic assumptions of parametric tests.

The Levene Test yielded a significance value of 0.981, indicating that the variance of both data groups was homogeneous ($p > 0.05$). Thus, the data met the requirements for a mean difference test using the Independent Sample T-Test.

The results of the Independent Sample T-Test showed a significance value (Sig. 2-tailed) of 0.308 (> 0.05), so it can be concluded that there is no significant difference between the maximum daily average rainfall at Patrang and Sumbersari Stations during the 2012–2022 period. Both locations have relatively similar rainfall levels and can represent each other in hydrological analysis.

The Pearson correlation test results showed a correlation coefficient of $r = 0.983$, indicating a very strong linear relationship between rainfall data at the two stations. This correlation indicates that changes in rainfall patterns at one station are followed by similar patterns at the other station.

The uniformity of these results can be explained by the geographic and topographical conditions of the central Jember region. Patrang and Sumbersari stations are both located on a mid-land plateau, approximately 80–100 meters above sea level, and the distance between them is less than 5 km. This relatively similar topography results in a relatively homogeneous rainfall distribution in both regions.

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The small differences that occur can be influenced by variations in micro-topography, vegetation, and the influence of urban activities that create the urban heat island effect. These factors have the potential to increase local rainfall intensity around urban areas like Sumbersari.

The results of this analysis indicate that both stations have similar hydrological representation and can be used interchangeably in hydrological analyses, such as drainage planning, flood discharge design, and water resource management. The high correlation between observational data and CHIRPS data also strengthens the potential use of satellite data as an alternative source of rainfall information in areas with limited observation stations.

Thus, CHIRPS can be used as supplementary or validation data in hydrological analysis in Jember Regency. To improve accuracy at the microscale, bias calibration using linear regression or a topography-based approach is recommended.

Analysis of the 2012–2022 period shows a fluctuating annual rainfall pattern at both stations (Patrang and Sumbersari) with a relatively narrow annual range. Annual observational data for both stations and CHIRPS output are presented in the data table (2012–2022), which shows that differences between stations are generally small (average annual differences are around 5–10 mm).

Statistics, Shapiro Wilk normality test shows $p > 0.05$ so that the normality assumption is met; Levene Test produces $p = 0.981$ (homogeneous variance); and the Independent Samples T-Test test gives Sig. (2-tailed) > 0.05 (reported 0.308 or 0.412 in some summaries), so that no significant difference was found in the average maximum daily rainfall between Patrang and Sumbersari Stations during 2012–2022.

Rainfall in a region is influenced not only by global atmospheric conditions but also by local characteristics such as topography, surface conditions, and regional development. At Patrang and Sumbersari Stations in Jember City, several factors play a role in shaping the variation and distribution of annual rainfall.

Topography is a significant factor influencing cloud formation and rainfall intensity. Both stations (Patrang and Sumbersari) are located in mid-latitude plains, with elevations ranging from 80–100 meters above sea level, so their characteristics are relatively similar.

The relatively uniform height at both stations causes the intensity and distribution of rainfall to be similar, so that the difference in rainfall data is only slight.

The results of this study indicate that rainfall characteristics at Patrang and Sumbersari Stations have strong similarities, providing important hydrological implications. First, both stations can be substituted for each other in hydrological analysis because there are no significant differences based on statistical tests. Second, data from both stations can be used in drainage planning, rainfall frequency analysis, and flood discharge calculations without reducing model accuracy. Third, CHIRPS data can be used as a complement and substitute in areas with minimal rainfall stations because it has proven to have high agreement with observational data. Fourth, the integration of CHIRPS data and observational data can improve the quality of hydrological modeling, especially in spatial analysis of rainfall. Thus, the use of these three data sources provides significant benefits for water resources planning and flood control in Jember Regency.

Conclusion and Recommendation

This study found that there was no significant difference in the maximum daily average rainfall between Patrang and Sumbersari Stations in Jember City for the period 2012-2022, with an Independent Sample T-Test significance value of 0.308 to 0.412 ($p > 0.05$), a Shapiro-Wilk normality test that was met, and a Pearson correlation of $r = 0.983$ indicating similar hydrological characteristics of both stations. [Gunasti et al., 2023] CHIRPS data also has a high agreement with observations, allowing its use as an alternative in areas with few stations. However, limitations of the study include a relatively short 11-year data period for long-term trends, the absence of topography-specific bias correction, and a focus only on maximum rainfall without detailed seasonal variables.

As a practical implication, these results support inter-station data substitution for drainage planning, flood discharge, and water management in Jember, as well as the integration of CHIRPS in the BMKG hydrological model. Suggestions for further research include extending the period to 30 years, applying linear regression for elevation-based CHIRPS calibration, GIS spatial analysis with Himawari-8 data, and non-parametric tests such as Mann-Whitney for non-normal data in the dry season. [Gunasti, 2024] This approach will improve the accuracy of flood predictions in East Java, which is

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vulnerable to monsoon variability.

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