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Extreme Climate Index Projection using the Shared Socioeconomic Pathways Model (SSP 5-8.5) in Jambi Province 2026-2100

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Abstract
Introduction: *Global climate change has caused an increase in the frequency and intensity of extreme rain events, including in Jambi Province which is vulnerable due to geographical conditions, land use intensity and the dominance of the plantation sector. Extreme rain events have the potential to cause flooding, damage infrastructure and disrupt food security, resulting in future climate projections to support mitigation and adaptation efforts. .* ***Objective:*** *The aim of the research is to project changes in extreme climate indices and analyze their spatial distribution patterns and impacts.* ***Methods****: The data used includes observed rainfall from 41 BMKG rain posts, CHIRPS reanalysis data, and CMIP6 model data for historical and projection periods.* ***Results and Discussion:*** *The research results show that most extreme rainfall indices have increased until the end of the 21st century. Intensity indices such as PRCPTot, RX1day, RX5day, R95p, and R99p show a significant upward trend, indicating an increase in very heavy rain events.* ***Conclusion:*** *Spatially, the central region is the area most vulnerable to increased rainfall extremes.*

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Introduction

Current global climate change is increasingly affecting regional weather and climate dynamics in many parts of the world, including Indonesia. Increasing greenhouse gas concentrations due to human activities—such as burning fossil fuels, land-use change, and deforestation—have triggered global warming that drives climate change, including increases in the magnitude and frequency of extreme climate events (Adrianti, 2024). Consistent with this, the Intergovernmental Panel on Climate Change reports that the frequency of extreme rainfall events will increase as global warming intensifies (SK Gulev et al., 2021). Jambi Province on Sumatra is among the regions highly sensitive to climate variability and extreme rainfall changes due to its geographic characteristics, intensive land use (e.g., oil palm and rubber plantations), and the dominant role of agriculture and plantations in its economic structure (BPS Jambi, 2020). Rising rainfall extremes in this region can trigger flooding that damages infrastructure and settlements, while also disrupting agricultural stability, reducing food security, and constraining sustainable economic development (Hidayat et al., 2019).

To understand future risks of rainfall extremes in Jambi, a scenario-based projection approach is needed. Shared Socioeconomic Pathways (SSP) provide widely used development–emissions scenarios for projecting future climate and socioeconomic conditions; SSP5-8.5 represents a high-growth pathway that remains highly dependent on fossil fuels and thus produces very high greenhouse gas emissions (O'Neill et al., 2017; Riahi et al., 2017). In this study, projections under SSP5-8.5 are combined with extreme rainfall indices developed by the Expert Team on Climate Change Detection and Indices (ETCCDI) to systematically describe how rainfall extremes may change over time (Zhang et al., 2011). Because rainfall projections from Global Climate Models—particularly the CMIP6 suite that supports the latest IPCC assessment—remain challenging at regional scales in the tropics due to resolution limits and imperfect representation of local processes, their outputs need to be evaluated and adjusted against observational references to improve regional reliability (Hausfather, 2020); (Eyring et al., 2016); (SK, Gulev et al., 2021).

Therefore, this research adopts a clear workflow: (1) establishing an observational baseline using CHIRPS as a spatial rainfall reference, (2) applying bias correction using Quantile Mapping (QM) to reduce systematic errors in CMIP6 rainfall outputs, (3) calculating ETCCDI extreme rainfall indices from the corrected data, (4) assessing changes using trend metrics (slope and statistical significance), and (5) producing spatial maps to identify hotspots of increasing risk. Given the limited number of studies that specifically project extreme rainfall indices for Jambi Province, this approach is essential to provide more robust, regionally relevant evidence for adaptation and mitigation planning. By projecting extreme rainfall indices for 2026–2100, the results are expected to support water resource management, spatial planning, and protection of infrastructure and sustainable agriculture in Jambi Province in facing future extreme climate risks.

Method

This research was conducted using quantitative research methods. In accordance with the opinion (Abdullah et al., 2022) which defines quantitative research as a systematic investigation of phenomena that collects measurable data using statistical, mathematical or computational techniques. According to Emzir (2008), The quantitative approach is an approach that primarily uses a post-positivist paradigm in developing science (such as thinking about cause and effect, reduction to variables, hypotheses and specific questions using measurement and observation, and theory testing), using research strategies such as experiments and surveys that require statistical data. Therefore, quantitative research requires a lot of use of numbers, starting from data collection, interpretation of the data, and presentation of the results (Arikunto, 2006). This research was conducted for 2 (two) months, from September 2025 to October 2025. The research location is in the network of rainfall observation posts of the Jambi Climatology Station. The observation posts selected were posts with data lengths of more than or equal to 15 (fifteen) years. The type of data collected in this study includes secondary data. Observational rainfall data was obtained from the BMKG Technical Implementation Unit (UPT) in Jambi, namely the Jambi Climatology Station. Meanwhile, reanalyzed rainfall data, historical rainfall model data, and projected rainfall model data are open-source data that can be directly downloaded from the data provider's website.

Results and Discussion

CHIRPS Data Correction With Observation Data

An analysis of 41 research stations shows that before data correction, the CHIRPS data (blue dots) experienced a biased underestimation, or a consistent underestimation of the actual condition. The blue dots tended to be below the observation line (black dots), particularly in the middle to high quantiles representing moderate to extreme rainfall events. This underestimation phenomenon is a common bias in satellite precipitation data due to limited spatial resolution and limitations in capturing intense local rainfall phenomena (Toté et al., 2015). Such biases can have significant impacts on hydrological applications as they can potentially lead to inappropriate water infrastructure design and inaccurate flood risk estimates.

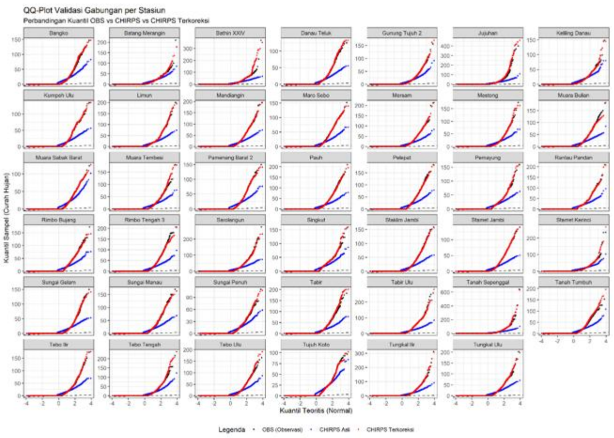

Figure 1 QQ-Plot Comparison of Observational Rainfall Data with CHIRPS and Corrected CHIRPS

Overall, validation using QQ-Plot proves that Quantile Mapping is able to correct bias in CHIRPS data well, producing a dataset with a distribution that is much more representative of actual rainfall conditions in the field, although there are still limitations in handling extreme values.

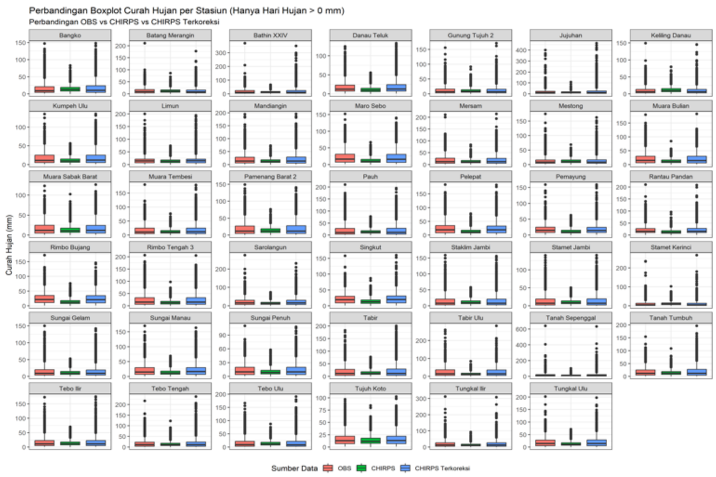

Figure 2 Boxplot Comparison of Observational Rainfall Data with CHIRPS and Corrected CHIRPS

In addition to the QQ-Plot analysis, the performance of the rainfall data was also evaluated using a boxplot analysis, as shown in Figure 4.2. This boxplot depicts the distribution of daily rainfall (only for days with rainfall >0 mm) at each observation station, comparing three data sources: OBS (field observations), CHIRPS, and Corrected CHIRPS. In general, the boxplot pattern shows that the raw CHIRPS data (green) tends to have a lower median rainfall than the observed data (red). This is consistent with the findings from the previous QQ-Plot, where CHIRPS showed an underestimation bias, especially at moderate to high rainfall intensities. The interquartile range in CHIRPS also appears narrower at many stations, indicating that the variation in CHIRPS data is smaller than the variation in actual observations in the field.

Several stations, such as Bangko, Danau Teluk, Limun, Staklim Jambi, and Sungai Penuh, showed excellent results, with the median and distribution of the Corrected CHIRPS data nearly identical to the OBS data. However, at several stations with extreme rainfall variations, such as Tanah Sepenggal, Bathin XXIV, Mersam, Sarolangun, and Tebo Tengah, slight differences remained in the upper quartile. This indicates that while bias correction is generally effective, there are still small deviations for rare extreme rainfall events, as confirmed by the previous QQ-Plot results. Thus, the boxplot analysis results reinforce the conclusion that the application of the Quantile Mapping method effectively corrects the underestimation bias in the CHIRPS data. The Corrected CHIRPS data not only demonstrates a good fit to the probabilistic distribution (as demonstrated by the QQ-Plot), but also displays descriptive statistical characteristics consistent with the observed data at each station.

Correction of CHIRPS Data with CMIP6 Data

Validation of rainfall data from 41 rain gauge stations shows a consistent pattern between the original CMIP6, corrected CHIRPS, and corrected CMIP6. In general, the original CMIP6 data shows significant deviations from the CHIRPS data, particularly in the form of biased underestimation at the mid- to high-quantile levels. This is clearly visible from the blue dots that lie well below the black dotted line at most stations. This condition aligns with the findings of Lange (2019), who emphasized that global climate models, although useful for large-scale simulations, often fail to represent extreme precipitation at the local level due to limited spatial resolution. In contrast, CHIRPS, which has undergone a bias correction process using the Quantile Mapping method, shows substantial distribution improvements.

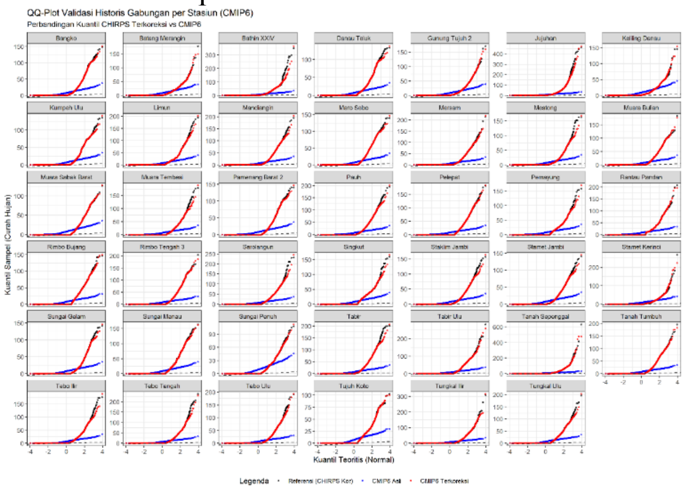

Figure 3 QQ-Plot Comparison of CHIRPS Rainfall Data Corrected with CMIP6 and Corrected CMIP6

The corrected CMIP6 model shows a significant improvement in distribution quality. At almost all stations, the red dots overlap with the observation points (black). At stations such as Bangko, Batang Merangin, Danau Teluk, Gunung Tujuh, and Maro Sebo, the corrected CMIP6 data distribution almost perfectly matches the observational distribution, indicating successful bias correction across the entire quantile range. However, at several other locations, such as Bathin XXIV, Mersam, Pauh, and Tebo Tengah, slight positive deviations are observed in the tails of the distribution, indicating a tendency for the corrected model to overestimate extreme rainfall. This phenomenon is understandable because the limited number of extreme rainfall samples makes the quantile mapping in the tails of the distribution less stable. (Cannon, 2018).

This QQ-Plot analysis shows that the original CMIP6 data consistently suffers from significant underestimation bias, the corrected CHIRPS can be a valid representation of local rainfall distribution, and the corrected CMIP6 is able to correct most of this bias with consistent results at almost all stations. Despite limitations at the extreme quantiles, overall the quantile-based bias correction method proves effective, and the corrected CMIP6 data can be used more accurately for climate change projection analyses.Proyeksi Indeks Iklim Ekstrem di Provinsi Jambi

Consecutive Dry Days (CDD)

The CDD index represents the maximum number of consecutive dry days in a year. The analysis of the CDD index in Jambi Province, based on the graph and projection table for the 2026–2100 period (Figure 4.5 and Table 4.1), shows a pattern of change that varies across observation stations. The data shows that most stations have slopes close to zero with relatively high p-values (>0.05), indicating that changes in the CDD index are statistically insignificant at most locations. A closer look at the graph and projection table reveals several stations that show a clearer trend in CDD changes, although not statistically significant. For example, Batang Merangin has a positive slope of 0.069 with a p-value of 0.18, indicating an increasing trend in the number of consecutive dry days. Conversely, Muara Sabak Barat and Rimbo Bujang show negative slopes of -0.069 and -0.052, respectively, indicating a decrease in CDD duration, resulting in more evenly distributed rainfall. This condition is likely influenced by the location of Jambi's eastern coastal region, which is more affected by ocean circulation and monsoons. Meanwhile, the Penuh and Manau rivers exhibit positive slopes (0.043 and 0.034), which, although small, could signal an early increase in the risk of seasonal drought in the western part of Jambi Province. The highest CDD index value is projected at Tungkal Ilir Station in 2043, with a dry day duration of 97 days, reflecting the potential for extreme drought in the region. 2043 is also a dominant year on a regional scale with the highest average CDD (71.20 days), indicating widespread drought conditions at most stations that year.

Table 1

Value of the Rate of Change of the CDD Index for the Period 2026-2100 at the Research Post of Jambi Province

Station	Slope	P-Value	Station	Slope	P-Value
Bangko	0	0.834	Rimbo Bujang	-0.052	0.299
Batang Merangin	0.069	0.18	Rimbo Tengah	0	0.784
Bathin XXIV	-0.027	0.561	Sarolangun	0	0.714
Danau Teluk	0	0.898	Singkut	0	0.979
Gunung Tujuh	0.025	0.593	Staklim Jambi	0	0.827
Jujuhan	0	0.798	Stamet Jambi	0	0.809
Keliling Danau	0.056	0.312	Stamet Kerinci	0.034	0.612
Kumpeh Ulu	-0.022	0.674	Sungai Gelam	0	0.812
Limun	0	0.935	Sungai Manau	0.034	0.621
Mandiangin	-0.027	0.589	Sungai Penuh	0.043	0.487
Maro Sebo	-0.022	0.667	Tabir	0	0.837
Mersam	-0.021	0.58	Tabir Ulu	0	0.798
Mestong	-0.038	0.51	Tanah Sepenggal	0	0.986
Muara Bulian	-0.036	0.558	Tanah Tumbuh	0	0.968
Muara Sabak Barat	-0.069	0.398	Tebo Ilir	0	0.931
Muara Tembesi	-0.035	0.534	Tebo Tengah	0	0.859
Pamenang Barat 2	-0.04	0.462	Tebo Ulu	0	0.906
Pauh	-0.027	0.552	Tujuh Koto	-0.02	0.631
Pelepat	-0.027	0.648	Tungkal Ilir	-0.04	0.546
Pemayung	0	0.77	Tungkal Ulu	-0.016	0.691
Rantau Pandan	0	0.895		-0.052	0.299

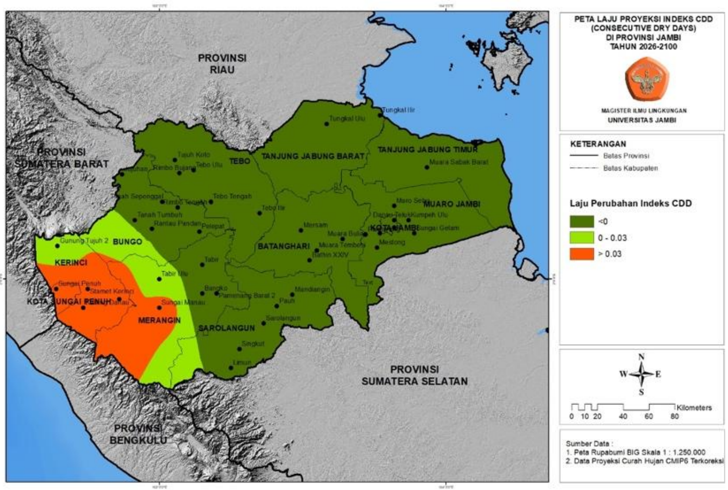

Figure 4 Spatial Map of the Rate of Change of the CDD Index for the Period 2026-2100 at the Jambi Province Post

In the spatial map of the projected CDD rate of change (Figure 4.6), the spatial distribution of index changes is divided into three categories: green indicates a downward trend (slope <0), light green indicates a stagnant trend (slope 0–0.3), and orange indicates an upward trend (slope >0.3). The spatial analysis indicates that most areas of Jambi are experiencing a downward trend, particularly in the central to eastern regions of the province, such as Muaro Jambi, Batanghari, and West and East Tanjung Jabung. This indicates a decreasing number of consecutive dry days, which could indicate an increase in rainfall frequency. Conversely, areas in the west (e.g., Kerinci and its surroundings) show an upward trend in CDD, indicating the potential for a longer dry period. This phenomenon is consistent with the topographic differences between lowlands and highlands, which influence rainfall dynamics. (Qian et al., 2010).

The implications of these results are significant for the agricultural and water resources sectors. Western regions, which tend to experience increasing CDD, need to increase irrigation capacity and implement water-saving technologies to anticipate the risk of drought. Conversely, central and eastern regions, which tend to experience decreasing CDD, face challenges in the form of potential flooding and inundation due to higher rainfall intensity, necessitating the strengthening of flood control infrastructure and drainage management. This aligns with IPCC recommendations. (SK, Gulev et al., 2021) Adaptation must be based on local conditions because the impacts of climate change are highly heterogeneous across spatial scales. Statistical test results show that most p-values are relatively large (generally >0.3), indicating that the trend change is not yet statistically significant. This does not mean there is no change, but rather that the detected changes are still weak considering the observation period used. Studies of climate extremes typically require longer time series (>50 years) with high-quality data to clearly demonstrate trends. (Zhang et al., 2011). Therefore, although largely statistically insignificant, the projection results remain relevant as a basis for mitigation and early warning systems in addressing future climate change.

Thus, it can be concluded that the CDD projection pattern in Jambi Province exhibits significant spatial variation between the western and eastern regions, with topographic factors, regional atmospheric circulation, and the influence of global climate variability such as ENSO potentially being the main drivers of these differences(Qian et al., 2010). Area-based adaptation strategies are important by implementing water conservation technologies in areas with increasing CDD trends, and flood control and excess water supply in areas with decreasing trends

***Consecutive Wet Days* (CWD)**

The CWD index represents the maximum number of consecutive rainy days in a year. Analysis of the CWD index for the 2026–2100 projection period in Jambi Province shows a trend quite different from the CDD index. Based on the graph and table of projection analysis results (Figure 4.7 and Table 4.2), most stations exhibit a positive slope, although the p-value varies. This indicates a trend towards an increase in the number of consecutive rainy days in most areas. The increase in CWD can be interpreted as an indication of an increase in the duration of the wet period, which has the potential to Several stations have statistically significant slopes (p-value < 0.05). For example, Rimbo Bujang (slope 0.046; p-value 0.008), Rimbo Tengah 3 (0.037; p-value 0.039), and Muara Tembesi (0.033; p-value 0.037). These stations clearly show an increasing trend in consecutive rainy days, potentially increasing the intensity of wet periods in the region. In contrast, several stations such as Bangko, Batang Merangin, and Keliling Danau show slopes approaching zero, indicating no significant change in the projected observation period. The CWD index showed its highest maximum value at Batang Merangin Station in 2085 with a total of 40 consecutive rainy days, marking an extreme prolonged wet period. 2077 was recorded as the dominant year overall with the highest average CWD (21.63 days), indicating an increasing trend in consecutive rainy periods in many areas that year.

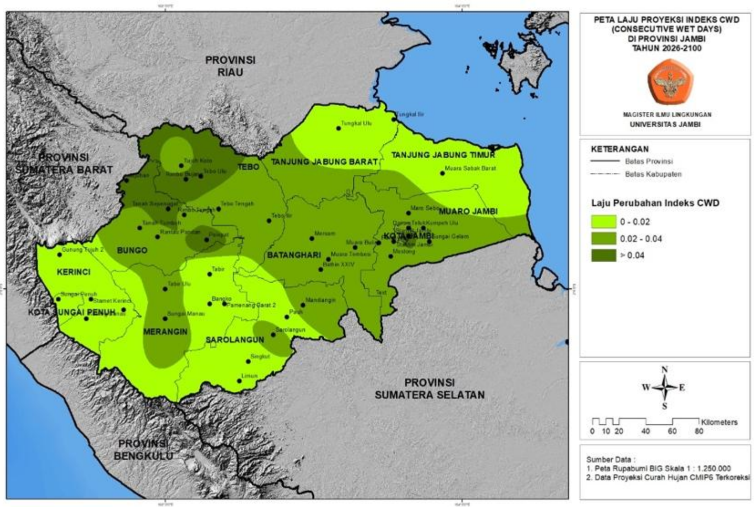

Figure 5 Spatial Map of the Rate of Change of the CWD Index for the Period 2026-2100 at the Jambi Province Post Office

Based on the spatial projection map, all regions in Jambi Province are projected to experience an increase in the CWD index with varying intensity, with the central region of Jambi Province tending to experience a greater rate of change in the CWD index compared to the eastern and western regions. This distribution aligns with the CDD, which shows a greater decline in most areas of Jambi Province. Thus, there are indications that future rainfall projections are more likely to increase wet periods than dry periods. This aligns with the results of the IPCC AR6 study, which stated that the intensification of the global hydrological cycle due to climate change will increase periods of heavy and prolonged rainfall in tropical regions. (SK, Gulev et al., 2021).

Although some trends appear significant, many stations still have high p-values, indicating local-scale projection uncertainty. This is understandable, given that tropical rainfall variability is complex and influenced by both regional and global factors, including ENSO and IOD. (Chen et al., 2023). The CWD projection results for Jambi Province confirm a climate shift toward longer wet periods in most regions. This situation necessitates relevant adaptation policies, particularly in the agricultural sector and water resources management, to minimize the negative impacts of extreme climate events. A comparison of CDD and CWD demonstrates interconnected climate dynamics, whereby as CDD decreases, CWD tends to increase. The eastern region of Jambi experiences a combination of decreasing CDD and increasing CWD, indicating a greater potential for flooding. Conversely, the western region shows a trend toward increasing CDD despite also increasing CWD, indicating the risk of seasonal drought remains, along with the potential for flash floods during the rainy season.

PRPCTot

PRCPTot is an index that represents the amount of rainfall in one year. The results of the PRCPTOT (Total Annual Rainfall) index projection analysis in Jambi Province for the period 2026–2100 show a very clear trend, namely an increase in the amount of annual rainfall at almost all observation stations, most stations have a positive slope with a high level of significance (p-value <0.05), which means that this trend of increasing annual rainfall is not just a random fluctuation, but reflects a fairly consistent pattern of climate change. Only a small number of stations show a positive trend but it is not statistically significant, for example Batang Merangin with a slope of 4.811 and a p-value of 0.194 or Sungai Penuh with a slope of 2.554 and a p-value of 0.437. However, the dominance of significant results at more than 90% of stations strengthens the conclusion that Jambi Province will experience an increase in annual rainfall in the future.

Table 2

Value of the Rate of Change of the PRCPTot Index for the Period 2026-2100 at the Jambi Province Research Post

Station	Slope	P-Value	Station	Slope	P-Value
Bangko	16.694	0.002	Rimbo Bujang	25.948	0.001
Batang Merangin	4.811	0.194	Rimbo Tengah 3	26.944	0.001
Bathin XXIV	29.866	0.001	Sarolangun	23.548	0.001
Danau Teluk	18.645	0.001	Singkut	14.148	0.004
Gunung Tujuh 2	6.443	0.071	Staklim Jambi	20.298	0.001
Jujuhan	33.985	0.001	Stamet Jambi	17.15	0.001
Keliling Danau	2.352	0.39	Stamet Kerinci	4.58	0.151
Kumpeh Ulu	16.718	0.001	Sungai Gelam	14.011	0.001
Limun	14.507	0.005	Sungai Manau	12.438	0.048
Mandiangin	27.101	0.001	Sungai Penuh	2.554	0.437
Maro Sebo	19.956	0.001	Tabir	23.609	0.001
Mersam	28.436	0.001	Tabir Ulu	17.484	0.007
Mestong	17.708	0.001	Tanah Sepenggal	26.803	0.001
Muara Bulian	25.805	0.001	Tanah Tumbuh	18.848	0.001
Muara Sabak Barat	12.088	0.001	Tebo Ilir	24.104	0.001
Muara Tembesi	24.881	0.001	Tebo Tengah	26.496	0.001
Pamenang Barat 2	18.213	0.001	Tebo Ulu	26.181	0.001
Pauh	26.4	0.001	Tujuh Koto	18.426	0.001
Pelepat	24.066	0.001	Tungkal Ilir	22.676	0.001
Pemayung	18.772	0.001	Tungkal Ulu	23.741	0.001
Rantau Pandan	18.195	0.001			

The increase in annual rainfall detected by the PRCPTOT index indicates an intensification of the hydrological cycle in the Jambi region. According to the IPCC AR6 report, tropical regions are projected to become wetter as the atmosphere's capacity to hold water vapor increases due to global warming. (SK Gulev et al., 2021). The implications of this increase in annual rainfall are complex. On the one hand, increased water supply can be beneficial for the agricultural sector, particularly for rice paddies, which require a relatively stable water supply. Increasing the annual rainfall index (PRCPTOT) also has the potential to strengthen groundwater reserves and improve surface water availability, which is essential for domestic and industrial consumption. However, on the other hand, increased annual rainfall also carries significant risks to the environment and infrastructure. Areas with lower topography, such as Muaro Jambi, Batanghari, and Tanjung Jabung, will face greater threats of inundation and seasonal flooding. Meanwhile, hilly areas in the west, such as Kerinci, face the threat of landslides and erosion due to persistently high rainfall intensity. Therefore, increasing PRCPTOT must be viewed ambivalently: as an opportunity for water availability, but also as a threat to ecosystem stability and the disaster sector, particularly hydrometeorological disasters. The PRCPTOT projection results also confirm that climate change in Jambi Province affects not only rainfall quantity but also the quality of its distribution throughout the year. The significant increase in annual rainfall across nearly all regions indicates that the upcoming rainy season will be wetter, with more intense rainfall that tends to be concentrated in certain periods.

R10mm and R20mm

The projections of R10mm (annual number of days with daily rainfall ⩾10 mm) and R20mm (annual number of days with daily rainfall ⩾20 mm) indicate a robust increase in the frequency of heavy rainfall across Jambi Province during 2026 – 2100. Most stations show positive and statistically significant slopes (figures 4.11, 4.12; tables 4.4, 4.5), suggesting that both moderate-to-heavy and heavy rainfall days are expected to become more common. Notably, Bathin XXIV, Muara Tembesi, and Rimbo Bujang exhibit slopes above 0.3 with p-values <0.01, reflecting a strong upward trend. The highest R10mm value occurs at Rantau Pandan in 2092 (154 days), while 2096 emerges as the year with the highest regional mean (117.51 days), indicating broad intensification in rainfall-day frequency. For R20mm, Singkut records the maximum in 2096 (116 days), whereas 2092 is the dominant year regionally (82.95 days). Spatially (Figure 4.13), the strongest increases in R10mm (>0.2) concentrate in central–eastern Jambi (Muaro Jambi, East/West Tanjung Jabung, Batanghari, Bungo, and Tebo), while western highland areas (Kerinci, Merangin, and Sungai Penuh) show lower increases (≈0 – 0.2). This shift is policy-relevant because rising heavy-rainfall frequency increases flash-flood potential, urban inundation risk, and slope instability, consistent with evidence that extreme precipitation intensity is strengthening in Southeast Asia (SK Gulev et al., 2021).

R95p and R99p

R95p (annual rainfall total from events above the 95th percentile) and R99p (annual rainfall total from events above the 99th percentile) show the clearest signal of intensifying extremes, with significant upward trends at nearly all stations (p-values <0.05). For R95p, stations such as Bathin XXIV, Jujuhan, and Mestong record slopes exceeding 20, indicating substantial growth in rainfall contribution from very wet days. For R99p, Bathin XXIV, Muara Tembesi, and Tebo Ilir show slopes above 8–13, suggesting a marked increase in the most extreme events. The year 2092 stands out as the dominant extreme year: Jujuhan reaches 5511.94 mm for R95p, and 3469.92 mm for R99p, while regional averages also peak in 2092 (R95p: 2900.95 mm; R99p: 1344.93 mm). These two indices are highly policy-relevant because they represent the upper tail of the rainfall distribution most closely linked to major disasters (flash floods, landslides, and infrastructure damage) and align with IPCC AR6 evidence that high-threshold extreme rainfall is increasing across maritime Southeast Asia (SK, Gulev et al., 2021).

Socio-economically, increased R95p/R99p implies heightened flood risk in the lower Batanghari Basin and greater exposure of coastal areas (West and East Tanjung Jabung) to flooding and potential seawater intrusion. This pattern is consistent with Indonesia-wide findings that extreme rainfall trends are increasingly driven by high-percentile events (Supari et al., 2020), supporting the interpretation that annual totals (PRCPTOT) may rise due to stronger event intensity rather than more rainy days.

RX1day and Rx5day

For event-based flood risk, Rx1day (maximum daily rainfall) and Rx5day (maximum consecutive five-day rainfall) provide the most direct hydrological signal of short- and multi-day extremes. Rx1day increases at most stations, with the largest changes in Bathin XXIV, Jujuhan, Tanah Sepenggal, and Tungkal Ilir, while smaller increases appear in central Jambi (Mandiangin, Mersam, Muara Tembesi, and Pauh) and the Kerinci highlands. Rx5day shows an even more consistent and widespread increase than Rx1day, with the strongest rises in Jujuhan and Tabir Ulu and significant increases also in Bathin XXIV, Rimbo Bujang, Tebo Ilir, Tungkal Ulu, and Sungai Penuh. Extremes are pronounced: Tanah Sepenggal records a maximum Rx1day of 479.78 mm (2044) and a maximum Rx5day of 1412.83 mm (2090). Regionally, 2092 is the dominant year for Rx1day (mean 177.56 mm), and 2090 for Rx5day (mean 617.88 mm), indicating increasing severity of both short bursts and sustained multi-day rainfall. The stronger signal in Rx5day is consistent with evidence from tropical regions that intensification is often more dominant on multi-day scales (Westra et al., 2014). Hydrologically, Rx1day is closely linked to flash floods in steep upstream catchments, whereas Rx5day better captures the risk of prolonged flooding and river overflows in middle and downstream areas. Overall, the projected increases are consistent with regional assessments that Southeast Asia will experience stronger and more frequent extreme rainfall under warming (SK, Gulev et al., 2021), implying that drainage capacity, flood-control infrastructure, and early warning systems must be strengthened—especially in hotspots with higher rates of change.

SDII

The Simple Daily Intensity Index (SDII), measuring average rainfall intensity on wet days, increases at almost all stations, with significant positive slopes ($p<0.05$) in most locations. The largest increases occur at Jujuhan (3.607), Tanah Sepenggal (3.137), and Bathin XXIV (2.828), while weaker and non-significant changes appear at Muara Sabak Barat (0.534, not significant) and Sungai Penuh (0.639, $p=0.072$). The maximum SDII is recorded at Jujuhan in 2097 (45.56 mm/day), and 2092 again emerges as a dominant year regionally (mean 30.91 mm), reinforcing the finding that rainfall events are projected to become more intense. This is highly relevant for water systems because higher SDII implies sharper discharge peaks and greater variability in the Batanghari watershed, increasing erosion and flood hazards. It also elevates landslide risk in western Jambi where steep terrain and land-cover changes can reduce slope stability. From a policy perspective, increasing SDII suggests the need for integrated adaptation measures targeting drainage upgrades, catchment protection, and risk-informed infrastructure planning, especially in economically active and flood-exposed areas along the Batanghari corridor.

Conclusion

Analysis of extreme climate projections in Jambi Province shows an increasing trend in most indices: PRCPTOT, R10mm, R20mm, R95p, R99p, Rx1day, Rx5day, and SDII. This increase indicates an increase in the intensity of extreme rainfall, the frequency of heavy rain days, and the annual rainfall accumulation. Meanwhile, the CDD index indicates the potential for a longer dry period in parts of Jambi Province, while the CWD index tends to increase in most areas of Jambi Province, indicating a longer chance of consecutive rainfall events. Spatial analysis shows an increase in most extreme rainfall indices, with higher magnitudes occurring predominantly in the central part of Jambi Province. These findings indicate that Jambi Province will face a higher risk of hydrometeorological disasters in the future. Increased extreme rainfall has the potential to trigger flooding, landslides, and inundation. The resulting impacts are expected to be significant on the agricultural sector, infrastructure, and the socio-economic life of the community.

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