

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

¹Octa Irawan*, ²Asmadi Sa'ad, ³Heri Junedi

¹ Environmental Science, Postgraduate School, Universitas Jambi, Indonesia*; email:

octa.bae@gmail.com

² Agroecotechnology Study Program, Faculty of Agriculture, Universitas Jambi, Indonesia

³ Universitas Jambi, Indonesia

*Correspondence

Article Information

Submitted: 02 October 2026

Accepted: 06 October 2026

Publish: 10 October 2026

Keyword: El Nino; Forest and Land Fire; Hotspot; ONI; Muaro Jambi;

Copyright holder: Octa Irawan, Asmadi Sa'ad, Heri Junedi

Year: 2026

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Abstract

Introduction: Lower respiratory tract infections remain a major cause of morbidity and antibiotic exposure in children. **Objective:** his study analyzed the influence of El Niño on forest and land fires during 2015–2025. **Method:** A mixed-methods design combined descriptive, correlation, and spatial analyses of ONI, rainfall, temperature, humidity, hotspots, and burned area, supported by interviews. **Results and Discussion:** Pearson analysis ($n = 132$) showed weak correlations between ONI and hotspots ($r = 0.167$; $p = 0.055$) and burned area ($r = 0.171$; $p = 0.050$), but a significant correlation with rainfall ($r = -0.239$; $p = 0.006$). One-month lagged rainfall correlated strongly with hotspots ($r = -0.425$; $p < 0.001$), while humidity showed the strongest correlations with hotspots ($r = -0.599$) and burned area ($r = -0.643$; both $p < 0.001$). **Conclusion:** El Niño indirectly increases fire risk through reduced rainfall and humidity, supporting early warning and peatland fire mitigation

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

Introduction

El Niño is a climate anomaly characterized by the warming of sea surface temperatures in the central and eastern Pacific (Niño 3.4 region), which reduces rainfall, raises air temperature, and lowers humidity across most of Indonesia, including Sumatra. These climatic changes can lead to prolonged drought, extending the dry season and reducing soil and peat moisture. As peatlands become increasingly dry, they become highly vulnerable to ignition and persistent forest and land fires. Thus, El Niño can initiate a sequence of environmental and health impacts through drought-induced peat drying, increased fire occurrence, and subsequent smoke exposure. Mechanistically, normal conditions are marked by trade winds blowing from the eastern to the western Pacific, causing warm water masses to accumulate around Indonesia and driving intense cloud and rainfall formation (the Walker circulation). When El Niño occurs, the trade winds weaken and even reverse direction, so the warm water mass shifts toward the central and eastern Pacific Ocean. This shift in the convection center reduces the supply of water vapor to western Indonesia, including Sumatra, and suppresses cloud formation for several consecutive months. The resulting rainfall deficit intensifies drought conditions and lowers peatland moisture, creating favorable conditions for fire ignition and spread. ENSO intensity is generally monitored through the Oceanic Niño Index (ONI), the three-month running mean of sea surface temperature anomalies in the Niño 3.4 region. Based on the magnitude of the ONI value, El Niño events are classified into weak, moderate, strong, and very strong categories as presented in Table 1 (Province, Hero, & Annisa, 2023; Dan et al., 2025).

Table 1
Classification of El Niño Intensity Based on ONI Value

El Niño Category	ONI Value (°C)
Weak	+0.5 to +0.9
Moderate	+1.0 to +1.4
Strong	+1.5 to +1.9
Very Strong	$\geq +2.0$

Classification of El Niño Intensity Based on ONI Value
and Position of Study-Period Extreme Values (2015-2025)

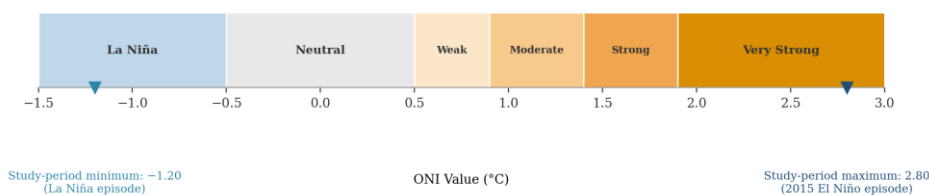


Figure 1. Visualization of the El Niño Intensity Classification Based on ONI Value

Muaro Jambi Regency, Jambi Province, has the second-largest peatland area in the province and has repeatedly experienced forest and land fires in years coinciding with El Niño, particularly 2015 and 2019 (Nurhayati et al, 2024). A recent study in the same regency confirms this pattern: hotspot distribution during the 2023 El Niño was concentrated mostly on peatland in Kumpeh Subdistrict, peaking in October when rainfall was low (Nurhayati et al, 2024). A further study based on Sentinel-2 imagery and the Normalized Burn Ratio (NBR) index in Muaro Jambi in 2024 also found that about 87% of the burned area was on peatland, with an inverse relationship between monthly rainfall

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

and hotspot count, and fire severity dominated by the moderate category (Hein et al., 2022). These findings support the first part of the pathway, in which El Niño-related rainfall deficits and drought increase peatland dryness and consequently the likelihood and extent of peat fires.

A similar pattern has been reported in other peatland regencies in Jambi Province and Sumatra. In Tanjung Jabung Timur Regency, of 1,696 annual hotspots during 2018–2022, 1,075 points were on peatland, with a strong negative correlation between rainfall and hotspots, and a sharp spike in the 2019 El Niño year (Enso et al., 2014; Nurhayati et al., 2024). In Banyuasin Regency, South Sumatra, burned area was positively correlated with hotspot count and negatively correlated with rainfall, peaking in the same El Niño year (Dan et al., 2025). At the island scale, a spatial analysis of rainfall anomalies and the Walker circulation during the 2018/2019 El Niño in Kalimantan found a fairly strong negative correlation between rainfall and hotspot density ($r = -0.55$), with rainfall contributing about 30% to the increase in fires, while the remaining 70% was influenced by other factors such as anthropogenic activity (Dan et al., 2025). A hotspot-density analysis in Sumatra and Kalimantan further confirmed that rainfall remains one of the most determining factors of surface fuel accumulation and fire intensity (Prayoga et al., 2017). A machine learning modeling approach on Bengkalis peatland, Riau, confirmed that peat fire vulnerability during the El Niño phase can be predicted from a combination of physiographic factors, peat physical properties, anthropogenic activity, and climate variables (Arrafi et al., 2024). Collectively, these studies indicate that drought acts as an important climatic link between El Niño and peat fire occurrence, although anthropogenic and land characteristics also influence whether dry peat ultimately burns.

Once peat fires occur, the pathway extends from an environmental hazard to a public health risk through smoke emissions and human exposure. Peat and forest fires generate dense smoke containing fine particulate matter (PM_{2.5}), which can be transported across affected communities and inhaled by the population. Exposure to smoke containing fine particulate matter (PM_{2.5}) from Indonesian forest and peatland fires has been reported to contribute to premature mortality and an increased respiratory disease burden nationally (Min et al., 2024), while a study of workers exposed to peat fire haze showed a significant decline in lung function compared with unexposed groups (Rietkerk et al., 2026). Therefore, the consequences of El Niño-related drought and peat fires extend beyond burned land: increased fire activity produces smoke and PM_{2.5}, increases population exposure, and may subsequently contribute to adverse respiratory and cardiovascular outcomes. On the policy side, an institutional evaluation of fire management in South Sumatra found that weak legal frameworks, limited law-enforcement involvement, and poor inter-agency coordination despite the involvement of the Ministry of Environment and Forestry (KLHK), BNPB, BRGM, and the military/police continue to hamper mitigation effectiveness (Arrafi et al., 2024). Meanwhile, a recent national-scale study found that undrained, intact peatland is far more fire-resistant than modified peatland, because a high water table dampens fire intensity and limits tree-cover loss—underscoring the importance of peat hydrological protection as a long-term mitigation strategy (Hayati et al., 2026). These findings indicate that mitigation should address the pathway at multiple stages, particularly by maintaining peat moisture to reduce fire occurrence, controlling fires to limit smoke and PM_{2.5} emissions, and reducing community exposure during haze episodes.

Although the relationship between El Niño and forest and land fires in Muaro Jambi has been examined in several short-term studies (per single fire event or season), studies that analyze this relationship as an integrated ten-year time series (2015–2025) combining

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

the ONI index, four climate elements, two fire indicators, spatial analysis, and institutional interview data at once remain limited. This is the gap that the present study seeks to address.

Based on the above, this study aims to: (1) analyze the pattern of change in rainfall, air temperature, and humidity in Muaro Jambi Regency during El Niño periods from 2015 to 2025; (2) analyze the relationship between El Niño intensity and forest and land fire occurrence based on hotspot count and burned area; and (3) identify the implications of the findings for forest and land fire mitigation efforts in Muaro Jambi Regency. This article is organized as follows: research methods; results and discussion, covering an overview of the study area, variation in El Niño intensity, patterns of change in climate elements, the spatial distribution of hotspots, the role of human activity, and mitigation implications; and finally, conclusions and recommendations.

Method

The study employed a mixed-methods design with a quantitative-dominant approach, in which quantitative statistical and spatial analyses were complemented by qualitative interview data to explain the observed patterns. The study focused on Muaro Jambi Regency, Jambi Province (1°15'–2°25' S and 103°30'–104°30' E), covering approximately 5,246 km². Secondary monthly data for 2015–2025 included the ONI index from the NOAA Climate Prediction Center; rainfall, air temperature, relative humidity, and hotspot count from BMKG Sultan Thaha Jambi; burned area from Manggala Agni Daops Jambi; and peatland distribution and administrative boundaries from the Jambi Provincial Forestry Office/Geospatial Information Agency. The quantitative dataset comprised 132 monthly observations, while qualitative data were collected from institutional informants representing BMKG Sultan Thaha Jambi, Jambi Provincial BPBD, and Manggala Agni Daops Jambi during March–May 2026.

Table 2
Research Variables and Data Sources

Variable	Data Source	Period / Resolution
ONI Index	NOAA Climate Prediction Center	Monthly, 2015–2025
Rainfall, air temperature, humidity	BMKG Sultan Thaha Jambi Meteorological Station	Monthly, 2015–2025
Hotspot count	BMKG Sultan Thaha Jambi Meteorological Station (MODIS/VIIRS imagery)	Monthly, 2015–2025
Burned area	Manggala Agni Daops Jambi	Monthly, 2015–2025
Peatland distribution & administrative boundaries	Jambi Provincial Forestry Office / Geospatial Information Agency	Latest available data
Institutional perceptions & community behavior	Interviews: BMKG, Jambi Provincial BPBD, Manggala Agni Daops Jambi	March–May 2026

Quantitative analysis consisted of descriptive statistics, Pearson correlation, and spatial analysis. Descriptive statistics included the mean, standard deviation, minimum, and maximum of ONI, rainfall, air temperature, relative humidity, hotspot count, and burned area. Pearson correlation was used to examine relationships among ONI, climate variables, and fire indicators using all 132 monthly observations, with statistical significance set at $\alpha = 0.05$ and calculated using SciPy in Python 3. A one-month lag correlation between rainfall and hotspot count was additionally examined to assess delayed drought effects on fire occurrence. Spatial analysis using GIS mapped hotspots and burned areas against subdistrict boundaries and peatland distribution, particularly comparing the 2015 and 2019 El Niño events.

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

The qualitative component used semi-structured interviews with institutional informants from BMKG, BPBD, and Manggala Agni who were selected based on their institutional roles and involvement in climate monitoring, disaster management, and forest and land fire control. Interviews explored community behavior, human activities, fire-control policies, and operational constraints. Interview data were analyzed thematically by identifying and grouping recurring information into key themes, particularly human contributions to fire occurrence, institutional responses, operational constraints, and mitigation effectiveness. The qualitative findings were then integrated with the quantitative results at the interpretation stage to explain and contextualize the statistical and spatial patterns, thereby completing the mixed-methods design.

Result and Discussion

General Overview of the Study Area

Muaro Jambi Regency is one of the regencies in Jambi Province with the second-largest peatland area in the province, distributed mainly across Kumpeh, Kumpeh Ulu, Maro Sebo, and Taman Rajo subdistricts (Figures 2 and 3). Most of the peatland area has been converted into plantation and settlement land, so the water table at many points is in a drained condition. This biophysical condition makes Muaro Jambi one of the regencies most vulnerable to forest and land fires in Jambi Province, consistent with its status as the location with the second-largest peatland area in the province (Nurhayati et al, 2024).

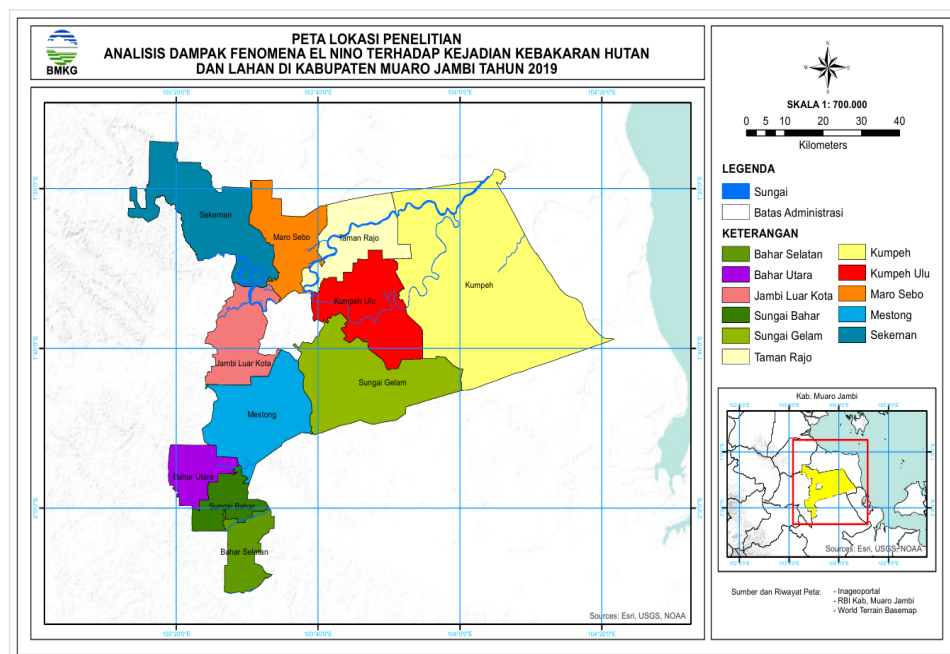


Figure 2. Research Location, Muaro Jambi Regency

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

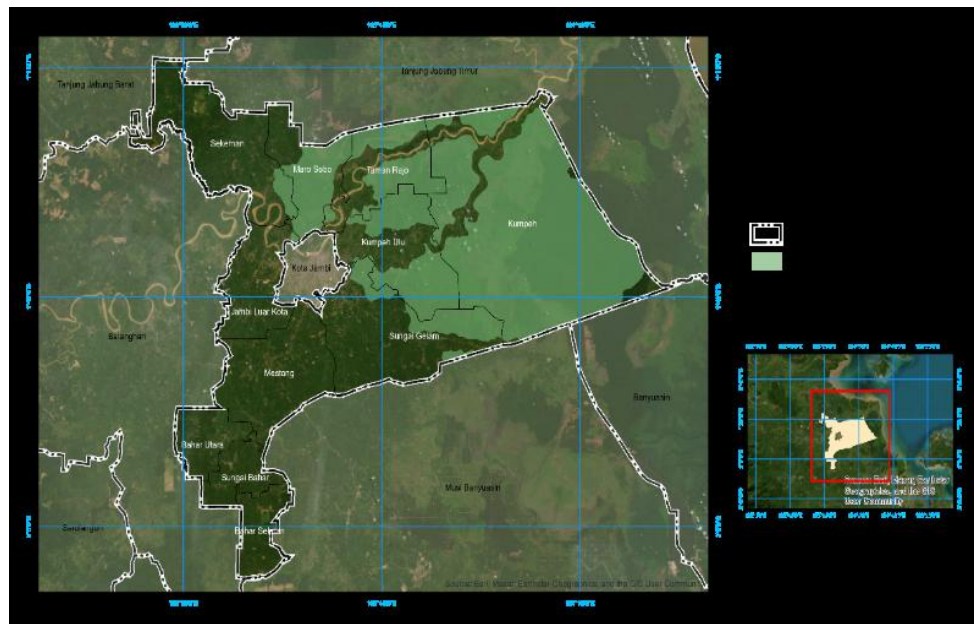


Figure 3. Peatland Area Map of Muaro Jambi Regency

Variation in El Niño Intensity, 2015–2025

Based on the monthly ONI index during 2015–2025, several El Niño episodes of differing intensity were identified with reference to the classification in Table 1. The year 2015 was recorded as a strong-to-very-strong El Niño episode, with an ONI value approaching the upper bound of the observation range (a time-series maximum of 2.80). The year 2019 showed a moderate-intensity El Niño episode. Between these two periods, the ONI index fluctuated in the neutral-to-weak-La-Niña range, as reflected in the minimum value of 1.20, indicating a La Niña episode. This alternating pattern of El Niño, neutral, and La Niña phases underlies the annual variation in hotspot count and burned area in Muaro Jambi Regency.

Descriptive Statistics of ONI, Hotspots, and Burned Area

The 2015–2025 time series ($n = 132$ months) shows a mean ONI of 0.17 with a range of -1.20 to 2.80 , a mean of 80.5 hotspots per month (maximum 1,210), and a mean burned area of 859.5 ha per month (maximum $\pm 17,800$ ha), as summarized in Table 3. The standard deviation, which is far larger than the mean for the hotspot and burned-area variables, shows that fire occurrence in Muaro Jambi is highly uneven throughout the year, concentrated in a few peak dry-season months, particularly when coinciding with El Niño episodes.

Table 3

Descriptive Statistics of ONI, Hotspot Count, and Burned Area in Muaro Jambi Regency, 2015–2025

	ONI	Hotspot Count	Burned Area (ha)
Valid (n)	132	132	132
Missing	0	0	0
Mean	0.1682	80.49	859.5
Std. Deviation	0.9238	172.8	2170.2
Minimum	-1.200	0.000	0.000
Maximum	2.800	1210	1.780×10^4

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

Descriptive Statistics of ONI, Hotspot Count, and Burned Area
Muaro Jambi Regency, 2015-2025 (n = 132 months)

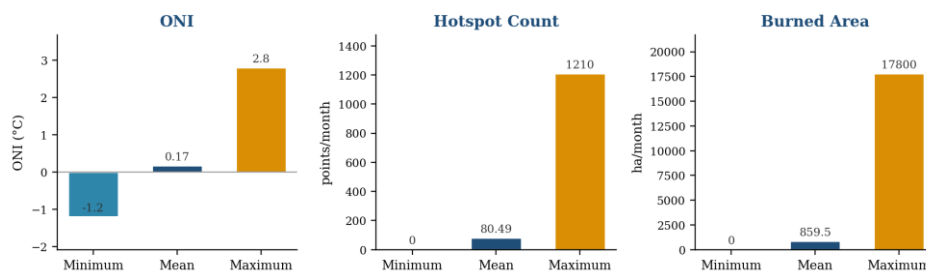


Figure 4. Comparison of Minimum, Mean, and Maximum Values of ONI, Hotspot Count, and Burned Area

In general, fire occurrence in Muaro Jambi Regency tends to increase during El Niño periods, particularly when intensity is moderate to strong, with peak occurrence in August–October. The years 2015 (strong El Niño) and 2019 (moderate El Niño) were recorded as the periods with the highest hotspot count and burned area over the study period. This pattern is consistent with findings from the 2023 El Niño, when the highest hotspot count in Muaro Jambi also occurred in October, coinciding with low monthly rainfall.

Pearson Correlation Analysis Results

The results of the Pearson correlation test on 132 monthly data points for 2015–2025 are presented in Table 4. Directly, ONI was only very weakly positively correlated, at the margin of significance, with hotspot count ($r = 0.167$; $p = 0.055$) and burned area ($r = 0.171$; $p = 0.050$). However, ONI was significantly negatively correlated with rainfall ($r = -0.239$; $p = 0.006$), confirming that the main mechanism by which El Niño affects forest and land fires in Muaro Jambi is indirect, through reduced rainfall rather than through a direct linear relationship with the number of fire points at monthly resolution.

Table 4

Pearson Correlation Matrix among ONI, Climate Elements, and Fire Indicators (n = 132)

Variable Pair	r (Pearson)	p-value	Remarks
ONI – Rainfall	-0.239	0.006	Significant
ONI – Air Temperature	0.070	0.423	Not significant
ONI – Humidity	-0.041	0.644	Not significant
ONI – Hotspot Count	0.167	0.055	Marginal
ONI – Burned Area	0.171	0.050	Marginal
Rainfall – Hotspot Count	-0.336	<0.001	Significant
Rainfall – Burned Area	-0.323	<0.001	Significant
Rainfall (1-month lag) – Hotspot Count	-0.425	<0.001	Significant
Air Temperature – Hotspot Count	0.138	0.114	Not significant
Air Temperature – Burned Area	0.217	0.012	Significant
Humidity – Hotspot Count	-0.599	<0.001	Significant
Humidity – Burned Area	-0.643	<0.001	Significant

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

Relationship of ONI, Rainfall (1-Month Lag), and Humidity with Fire Indicators
Muaro Jambi Regency, 2015-2025 (Pearson correlation analysis, $n = 132$)

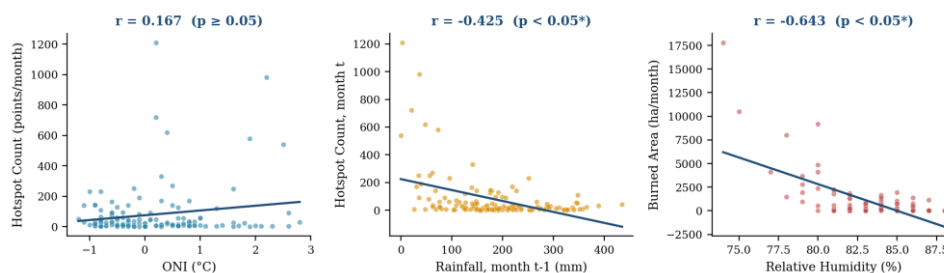


Figure 5. Scatter Plots of the Relationship between ONI, Rainfall (1-Month Lag), and Humidity with Fire Indicators

Among all the variables tested, humidity showed the strongest correlation with fire indicators, namely with hotspot count ($r = -0.599$; $p < 0.001$) and especially with burned area ($r = -0.643$; $p < 0.001$), both classified as strong. Concurrent-month rainfall was also significantly negatively correlated with hotspot count ($r = -0.336$; $p < 0.001$) and burned area ($r = -0.323$; $p < 0.001$). Interestingly, when rainfall was tested with a one-month lag against hotspot count, the correlation strength increased to moderate ($r = -0.425$; $p < 0.001$), stronger than the correlation without a lag. This finding quantitatively confirms the hypothesis raised qualitatively in the previous section, that the impact of reduced rainfall on increased hotspot occurrence only becomes clearly visible about a month later, consistent with the time needed for land and vegetation, particularly peat, to dry out gradually. Air temperature showed a weaker correlation and was only significant for burned area ($r = 0.217$; $p = 0.012$), but not significant for hotspot count ($r = 0.138$; $p = 0.114$).

Overall, these results indicate that El Niño acts as an indirect driver of fire occurrence in Muaro Jambi Regency: ONI significantly affects the decline in rainfall, and low rainfall, especially with a one-month lag, together with low humidity, subsequently correlates strongly with increases in hotspot count and burned area. This indirect chain of relationships is consistent with findings at the island scale in Kalimantan, where rainfall accounted for only about 30% of the variation in fire occurrence, with the remaining 70% influenced by other factors (Dan et al., 2025), and reinforces the argument that peatland moisture, not merely the global ENSO index, is the proximal determinant of fire risk (Putra et al, 2007; Rietkerk et al, 2026).

Rainfall Patterns during El Niño Periods

Rainfall is the climate element that changes most clearly during El Niño periods. Under normal conditions, Muaro Jambi still receives moderate-intensity rain during part of the dry season; however, when El Niño occurs, rainfall declines significantly over several consecutive months, particularly in the June–October period, so that vegetation and land, especially peat, become drier and more prone to fire. The rainfall decline in 2015 and 2019 lasted longer than in neutral years, so that soil moisture deficits accumulated and accelerated the drying of the upper peat layer. This negative relationship between rainfall and hotspots is consistent with findings at the island scale in Kalimantan, where rainfall anomalies during SON 2018–JJA 2019 ranged from -150 to 100 mm/month and were fairly strongly negatively correlated with hotspot density ($r = -0.55$) (Dan et al., 2025), as well as with studies in Tanjung Jabung Timur and Banyuasin that also found a strong negative correlation between rainfall and hotspots (Hero et al., 2023).

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

A hotspot-density analysis in Sumatra and Kalimantan further confirmed that rainfall remains one of the most determining factors of surface fuel accumulation (Prayoga et al., 2017). This descriptive finding is statistically reinforced in subsection 3.3.1: rainfall was significantly negatively correlated with hotspot count ($r = -0.336$; $p < 0.001$), and this correlation strengthened to $r = -0.425$ ($p < 0.001$) when tested with a one-month lag, confirming a delayed effect between the dry season and peak fire occurrence.

Air Temperature Patterns during El Niño Periods

Besides declining rainfall, El Niño periods in Muaro Jambi were also followed by an increase in mean monthly air temperature. Higher temperatures accelerate evapotranspiration from the soil surface and vegetation, so that moisture content in litter and surface fuel declines faster than under normal conditions. During the peak months of the 2015 and 2019 El Niño events, the combination of high air temperature and long sunshine duration further accelerated the drying of the shallow peat layer, one of the main preconditions for land to easily catch fire, whether from burning activity or from sparks originating from surrounding land. Statistically, air temperature showed a relatively weak correlation with fire indicators significant for burned area ($r = 0.217$; $p = 0.012$) but not significant for hotspot count ($r = 0.138$; $p = 0.114$), so the role of temperature is more one of reinforcing dry conditions already triggered by insufficient rainfall, rather than being an independent primary determinant (Gaber et al., 2025).

Relative Humidity Patterns during El Niño Periods

Relative humidity in Muaro Jambi also showed a consistent decline during El Niño periods, in line with declining rainfall and rising air temperature. Low humidity lowers the ignition point of vegetation and surface fuel, making fire easier to ignite and spread. The combination of these three climate elements low rainfall, high temperature, and low humidity creates atmospheric conditions highly conducive to fire spread on peatland and dry vegetated land, particularly during the extended dry-season peak caused by El Niño. Among all climate elements tested, humidity in fact showed the strongest correlation with fire indicators ($r = -0.599$ with hotspot count; $r = -0.643$ with burned area; both $p < 0.001$), making it the local climate variable most worth monitoring operationally as an early field indicator of fire risk (Nayar, 2020).

Spatial Distribution of Hotspots and Peatland Vulnerability

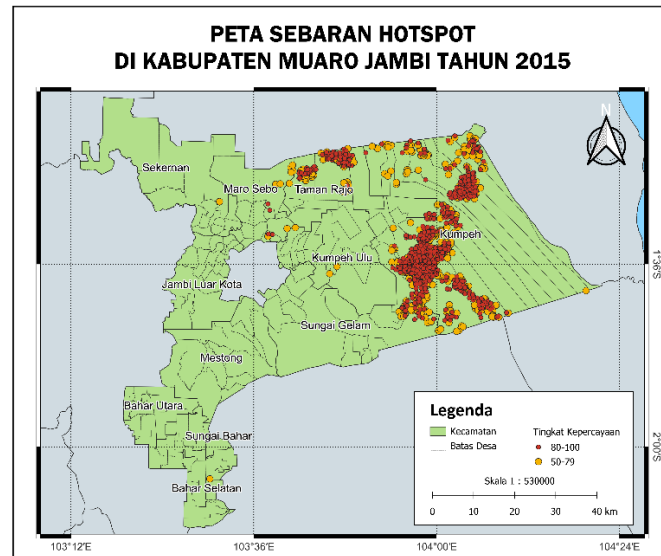


Figure 6. Hotspot Distribution in Muaro Jambi Regency, 2015 (Strong El Niño)

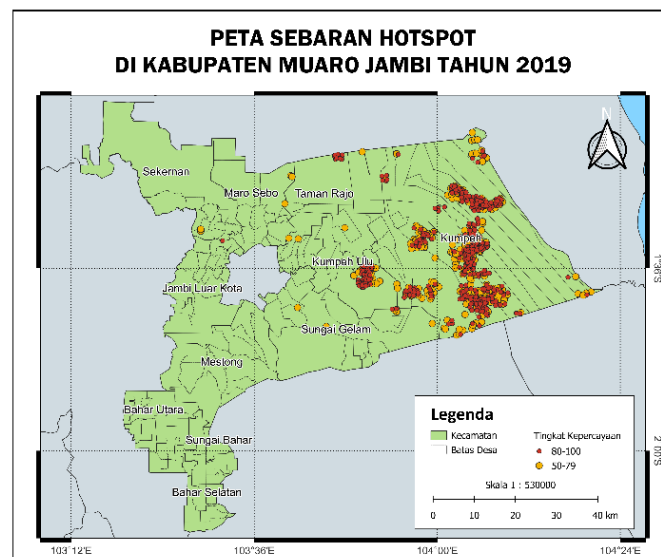


Figure 7. Hotspot Distribution in Muaro Jambi Regency, 2019 (Moderate El Niño)

Hotspot distribution in both years was concentrated in areas dominated by peatland and plantations, particularly in Kumpoh, Kumpoh Ulu, and surrounding subdistricts (Figures 6 and 7). In 2015, when El Niño intensity was in the strong category, the hotspot distribution appeared denser and more widespread compared with 2019, when El Niño intensity was moderate, although both years showed high density in the peatland area in the eastern part of the regency. This spatial pattern is consistent with a report based on Sentinel-2 imagery and the NBR index in Muaro Jambi in 2024, which found that 87.11% of the 1,415 ha burned area was on peatland, with moderate severity dominating (61.45%). This finding is also consistent with patterns in other peatland regencies in Jambi Province, such as Tanjung Jabung Timur, which recorded 1,075 of 1,696 annual hotspots during 2018–2022 on peatland (Arrafi et al., 2024).

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

From a peat hydrology perspective, the concentration of fire points in drained peatland is consistent with a recent national study showing that intact peatland (with a high water table) is far more fire-resistant than drained peatland, because wet conditions dampen fire intensity and limit tree-cover loss (Irawan, 2006; Hero et al., 2023). This reinforces the notion that Muaro Jambi's vulnerability to fire during El Niño is not solely due to the climate anomaly, but also to peat hydrological conditions that have been substantially altered by drainage for plantation purposes.

The Role of Human Activity in Forest and Land Fires

Although there is a clear relationship between El Niño intensity and increased hotspot count, this study's results confirm that El Niño is not the sole determinant of fire occurrence. In some periods with fairly low rainfall, the hotspot count was, in fact, not very high, indicating the role of other factors such as the intensity of field monitoring and community behavior in land management. Based on interviews with BMKG, the Jambi Provincial BPBD, and Manggala Agni Daops Jambi, land clearing by burning remains an important trigger for the emergence of fire points, mainly because it is considered cheaper and faster than non-burning land-clearing methods. Under normal climate conditions, the impact of small-scale land burning is relatively controllable; however, during El Niño, already very dry land conditions make fires spread easily beyond the intended area and difficult to extinguish.

This finding is consistent with an institutional evaluation in South Sumatra showing that weak law enforcement and poor inter-agency coordination continue to hamper fire-control effectiveness, even though various agencies such as KLHK, BNPB, BRGM, and the military/police have been involved in mitigation efforts (Cahyono, 2015; Arrafi et al., 2024). An informant from Manggala Agni Daops Jambi emphasized that limited field personnel and firefighting equipment, particularly in hard-to-access peatland areas, is one of the main obstacles to responding quickly to new fire points that emerge at the peak of the dry season.

Implications for Forest and Land Fire Mitigation

The impact of forest and land fires is not only ecological but also has broad implications for the health of surrounding communities. Exposure to smoke from Indonesian forest and peatland fires has been reported nationally to contribute to an increased risk of premature death and respiratory disease burden (Hein et al., 2022). While a study of workers exposed to peat fire haze showed a significant decline in lung function (Putra et al., 2007; Rietkerk et al., 2026). Fire mitigation efforts in Muaro Jambi therefore also need to be understood as part of public health protection, not merely as an environmental and forestry issue.

Based on this study's findings, information on El Niño and changes in climate elements can be used as part of an early-warning system for forest and land fires. When BMKG issues information on El Niño potential and declining rainfall, local government has time to strengthen patrols in vulnerable areas, particularly peatland and plantation areas in Kumpeh Subdistrict and surrounding areas, enhance daily hotspot monitoring, strengthen inter-agency coordination (BMKG, BPBD, Manggala Agni, and village governments), and intensify community education on the dangers and legal risks of land clearing by burning.

Beyond short-term preparedness measures, this study's findings also indicate the importance of a long-term mitigation strategy based on peat hydrological protection. Rewetting drained peatland, through the construction and maintenance of canal blocks,

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

has the potential to structurally reduce fire vulnerability, consistent with findings that peat with a high water table is far more fire-resistant (Hayati et al., 2026). This approach can be combined with technology-based water-table monitoring, as has begun to be implemented in Muaro Jambi during the 2023 El Niño (Nurhayati et al., 2024), so that early warning is based not only on regional climate data but also on site-level peat hydrological conditions.

Study Limitations

This study has several limitations that should be considered when interpreting its results. First, the correlation analysis uses monthly-resolution data and therefore cannot capture the daily dynamics of rainfall or fire occurrence in detail. Second, the Pearson correlation coefficient indicates the strength and direction of a linear relationship but does not by itself prove causation (correlation is not causation); confounding factors such as changes in land cover and the intensity of human activity from year to year were not quantitatively modeled in this study. Third, this study is a single-regency case study, so generalizing the findings to other peatland areas in Sumatra should be done with caution. Future research is recommended to use daily-resolution data, incorporate measurable human-activity variables (e.g., the area of land-clearing permits), and apply multivariate statistical models such as multiple regression or time-series models to test the relative contribution of each predictor simultaneously.

Conclusion

The findings indicate that El Niño is associated with forest and land fires in Muaro Jambi Regency primarily through its influence on local climatic conditions rather than through a direct relationship with fire occurrence. ONI showed only weak and marginal correlations with hotspot count ($r = 0.167$; $p = 0.055$) and burned area ($r = 0.171$; $p = 0.050$), while its relationship with declining rainfall was significant ($r = -0.239$; $p = 0.006$). Rainfall with a one-month lag ($r = -0.425$; $p < 0.001$) and humidity ($r = -0.599$ with hotspot count and $r = -0.643$ with burned area; both $p < 0.001$) showed stronger relationships with fire indicators. These results justify the interpretation that El Niño contributes to fire risk through reduced rainfall and humidity, which create drier conditions favorable for fire occurrence. Spatially, fires were concentrated in peatland- and plantation-dominated areas, particularly Kumpeh and Kumpeh Ulu, while human activities such as land clearing by burning and limitations in institutional oversight and coordination further influenced fire occurrence. Beyond ecological damage, peat fires also have public-health implications through smoke exposure.

Based on these findings, the authors emphasize that fire mitigation should integrate climate-based early warning with preventive management at the local level. ONI information and BMKG seasonal forecasts can support earlier preparedness before the peak dry season, particularly in vulnerable areas such as Kumpeh and Kumpeh Ulu. This should be complemented by stronger patrols and early firefighting capacity during August–October, peatland rewetting through canal-block maintenance, community education and affordable alternatives to burning, and improved inter-agency coordination. Future studies should further develop quantitative predictive models integrating ONI, local climate variables, and hotspot occurrence to improve the precision of forest and land fire early-warning systems in Muaro Jambi Regency

Octa Irawan, Asmadi Sa'ad, Heri Junedi/KESANS

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

Declaration of AI Assistance

AI Tools including Chat GPT, Gemini, Claude AI were used during the preparation of this manuscript. The AI Tools were used for grammar checking, paraphrasing and translating. The Authors have checked the output of the tools.

Reference

- Arrafi, M., Widayani, P., & Arjasakusuma, S. (2024). [Kajian Multitemporal Tingkat Keparaharan Kebakaran Hutan dan Lahan di Kabupaten Muaro Jambi Menggunakan Penginderaan Jauh](#). *Aerosp. Eng*, 1(3), 14.
- Cahyono, S. And. (2015). *FAKTOR-FAKTOR YANG MEMPENGARUHI KEBAKARAN HUTAN DI INDONESIA DAN IMPLIKASI KEBIJAKANNYA*. 3(1), 103–112.
- Dan, Hujan, Hotspot, Sebaran, Pulau, D. I., Mareta, Lesi, Wulandari, Yana Ranita, Putra, Raden, & Selatan, Lampung. (2025). [ANALISIS SPASIAL PENGARUH EL NIÑO 2018/2019 TERHADAP CURAH HUJAN DAN SEBARAN HOTSPOT DI PULAU KALIMANTAN](#). *JOURNAL ONLINE OF PHYSICS*, 11(1), 113-119 <https://doi.org/10.22437/jop.v11i1.47506>
- Enso, Fenómeno, Niño, El, & Oscilación, Sur. (2014). *Terhadap Pola Hujan Di Wilayah Maluku Dan Papua*. (Gambar 2), 71–76.
- Gaber, Mohamed Mohamed, Shokry, Hassan, Hassanin, Ahmed H., Awad, Said, Samy, Mahmoud, & Elkady, Marwa. (2025). [Novel palm peat lignocellulosic adsorbent derived from agricultural residues for efficient methylene blue dye removal from textile wastewater](#). *Applied Water Science*, 15(2). <https://doi.org/10.1007/s13201-025-02363-y>
- Hayati, Nur, Sitanggang, Imas Sukaesih, Prasetyo, Lilik Budi, & Syaufina, Lailan. (2026). [Logistic Regression Modeling of Peatland Fire Hotspots in Bengkalis District Using Integrated Environmental and Anthropogenic Drivers](#). *Journal of Information Systems and Informatics*, 8(2), 2495-2528 <https://doi.org/10.63158/journalisi.v8i2.1560>
- Hein, Lars, Spadaro, Joseph V, Ostro, Bart, Hammer, Melanie, Sumarga, Elham, & Salmayenti, Resti. (2022). [The health impacts of Indonesian peatland fires](#). *Environmental Health*, 1–16. <https://doi.org/10.1186/s12940-022-00872-w>
- Irawan, Bamabang. (2006). *Fenomena anomali iklim El Niño dan La Niña: kecenderungan jangka panjang dan pengaruhnya terhadap produksi pangan*. 24(1), 28–45.
- Min, Hein, Tian, Aodi, & Huang, He. (2024). [Advancements in the application of modified biochar for the removal of heavy metals and organic pollutants: short review](#). *Int J Sci Res Manag*, 12(06), 161-178. <https://doi.org/10.18535/ijserm/v12i06.c05>
- Nayar, Renu. (2020). [Assessment of water quality index and monitoring of pollutants by physico-chemical analysis in water bodies: a review](#). *International Journal of Engineering Research and Technology*, 9(01), 178-185. Retrieved from www.ijert.org
- Nurhayati, A. D., & Aulia, C. H. N. (2024). [Sebaran Hotspot dan Patroli Terpadu Pada Masa El-Nino 2023 Di Kabupaten Muaro Jambi](#). *Journal of Tropical Silviculture*, 15(03), 279-286. <https://doi.org/10.29244/j-siltrop.15.03.279-286>
- Prayoga, M. Bayu Rizky, Yananto, Ardila, & Kusumo, Ananto. (2017). *HUJAN DI PULAU SUMATERA DAN KALIMANTAN: Correlational Analysis between Hotspots Density and Rainfall in Sumatera and Kalimantan*. 18(1), 17–24.
- Putra, Erianto Indra, & Hayasaka, Hiroshi. (2007). *Carbon Emission from Severe Peat Fires in Mega Rice Project Area, Indonesia*. 2–3.
- Rietkerk, Max, & Staal, Arie. (2026). [Intact peatlands experience smaller fire impact on tree cover than modified peatlands and non-peatlands in Indonesia](#). *Frontiers in Forests and Global Change*, 9, 1840645. <https://doi.org/10.3389/ffgc.2026.1840645>

Octa Irawan, Asmadi Sa'ad, Heri Junedi/KESANS

The Effect of the El Niño Phenomenon on the Occurrence of Forest and Land Fires in Muaro Jambi Regency, Jambi Province

Saharjo, B. H., & Effendi, D. A. (2023). The effect of rainfall and forest and land fires in East Tanjung Jabung Regency, Jambi Province. <https://doi.org/10.29244/j-siltrop.14.02.126-131>