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# ANALYSIS OF FIRE POST PLACEMENT BASED ON FIRE RISK IN KATINGAN HILIR DISTRICT, KATINGAN REGENCY

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**Abstract**
This study aims to analyze fire vulnerability levels and determine the optimal placement of fire stations in Katingan Hilir District, Katingan Regency, Central Kalimantan. Using a quantitative method and spatial modeling approach, the research integrates ten years of NASA MODIS satellite data (2015–2024) focusing on three key variables: fire hotspots, rainfall, and land cover. Findings reveal that 48.5% of the 301 recorded fire hotspots were not covered by the three existing fire stations, with the highest concentration found in Hampangen Village. Based on spatial overlay modeling and a 15-minute response time standard, the study recommends establishing a new fire station in this high-risk area. This spatial assessment offers valuable input for adaptive spatial planning and aims to enhance the regional fire risk management system.

**Keywords:** ***Forest Fire, Spatial Analysis, Fire Station Placement***

## INTRODUCTION

Indonesia is known for its abundant natural resources, including forestry. Forest areas, particularly peat forests, play a vital role in maintaining environmental sustainability due to their function as carbon emission absorbers and protection of ecological systems.[1]Indonesia's peat forests are widespread, with approximately 30% of them located on the island of Kalimantan, particularly in Central Kalimantan Province, which has 2.65 million hectares of peatland. This area is a priority for provincial spatial planning protection due to its crucial role in maintaining ecosystem balance. However, this richness is accompanied by significant risks, such as recurring forest and land fires (KARHUTLA), which occur frequently, particularly during the dry season, and have a significant impact on the environment and people's lives. Forest and land fires in Central Kalimantan are generally caused by extreme drought conditions and dry, flammable peat. When fires occur in peatlands, embers can continue to smolder beneath the surface, making extinguishing difficult. In addition to natural factors, human activities such as land clearing by burning, burning garbage, and other negligence contribute to worsening conditions.[2]These fires not only cause material losses but also threaten lives, disrupt public health due to air pollution (ARI, asthma, and other lung diseases), and cause permanent damage to tropical forest ecosystems. They also contribute to carbon emissions, exacerbating the global climate crisis. The government has issued various regulations to control fire risks, including Minister of Public Works Regulation No. 20/PRT/M/2009 and Minister of Environment and Forestry Regulation No. 32 of 2016, which emphasize the importance of firefighting facilities and infrastructure, such as fire stations, firefighting vehicles, communication equipment, and firefighter personnel. However, prevention and response

[1]Anhar, Indah Pratiwi, Rina Mardiana, and Rai Sita. 2022. "The Impact of Forest and Peatland Fires on Humans and the Environment (Case Study: Bunsur Village, Sungai Apit District, Siak Regency, Riau Province)." Journal of Communication Science and Community Development 6 (1): 75–85.https://doi.org/https://doi.org/10.29244/jskpm.v6i1.967.

[2]Khotimah, Syarifah Khusnul, Rosalina Kumalawati, Nurlina, and Inu Kencana Hadi. 2024. "Hotspot Monitoring and Forest and Land Fire Mitigation in Katingan Regency 2019-2023." Multidisciplinary Journal of Science Warehouse 2: 5–12.https://doi.org/https://doi.org/10.59435/gjmi.v2i5.420.

efforts still face various challenges in the field.[3], including the limited number of fire stations, their less-than-strategic locations, and minimal public awareness and education about the dangers of fire. Katingan Regency, as one of the fire-prone areas in Central Kalimantan, requires special attention, especially due to its geographical location, which is dominated by peatlands and tropical forests that are prone to fire during the dry season.[4] Katingan Hilir District is one of the districts in Katingan Regency with a very high fire risk. The dense population, predominance of residential buildings and public facilities, and intense economic activity in this area increase the risk of fire. Fires can start quickly and spread widely if not handled quickly and appropriately. In addition to internal factors, external conditions such as long dry seasons and dry vegetation also exacerbate the vulnerability of this area. Therefore, early detection systems, public education, and adequate firefighting infrastructure are essential to anticipate future fire incidents. Katingan Regency currently has nine fire stations spread across various regions, but this number is not commensurate with the regency's area of 17,800 km².

The existence of these posts is not optimal in reaching vulnerable areas, especially areas with high mobility such as Katingan Hilir. Therefore, spatial analysis is needed to review the effectiveness of fire station distribution, as well as identify new strategic locations that can be reached within the ideal response time, which is no more than 15 minutes, as stipulated in the Decree of the Minister of Public Works Regulation No. 25 of 2008. The fires that occur in vulnerable areas like Katingan Hilir District are not simply a technical issue or a natural disaster, but are also closely related to social and cultural aspects of the community. In many cases, land clearing by burning is still considered a cheap and quick method, despite its dangers.[5]Public awareness of the dangers of fire, from a health, economic, and environmental perspective, still needs to be increased through ongoing education and local cultural approaches. Furthermore, weak law enforcement against land fire perpetrators and limited reporting and rapid response systems are major obstacles to fire control.[6]Therefore, solutions to fire problems cannot rely solely on infrastructure and equipment, but must also encompass aspects of community behavior and the institutional capacity of local governments.

The need for a representative fire station in Katingan Hilir District is increasingly pressing, given that this area is not only densely populated but also serves as the center of government and economic activity in Katingan Regency. Important buildings such as government offices, health facilities, schools, markets, and densely populated residential areas create a high risk of fire damage. In the context of spatial planning and disaster risk management, the availability of fire stations must be aligned with the service area coverage and effective response speed. Fire stations that are too far away will slow response times, which can be fatal, especially in large fires or fires that occur in densely populated areas. Therefore, spatial mapping and analysis are needed to identify strategic locations and prioritize the construction of new posts. Through this research, the Katingan Regency Government is expected to obtain a comprehensive overview of the existing conditions and the need for more ideal fire stations that meet national standards. The results are expected to provide input for developing more adaptive spatial planning policies for fire disasters and improve the preparedness of the community and relevant agencies. Furthermore, the spatial approach used in this research can serve as an example for applying data technology to fire mitigation planning in other areas with similar characteristics.

## RESEARCH METHODS

This study uses a quantitative method with a spatial modeling approach to analyze the level of fire vulnerability and determine the need for fire stations in Katingan Hilir District, Central Kalimantan. The analysis was conducted using ArcGIS 10.8 software by overlaying data in SHP format, using indicators such as hotspots, rainfall, land cover, and surface temperature, to produce a thematic map depicting fire risk and the effectiveness of fire service coverage. Primary data was obtained through observation, visual documentation, and interviews with DAMKAR officers, while secondary data included thematic maps and spatial data from various agencies, including

[3]Akhmaddhian, Suwari. 2016. “Enforcement of Environmental Law and Its Impact on Economic Growth in Indonesia (Study of Forest Fires in 2015).” UNIFIKASI: Journal of Legal Studies 3 (1): 1–35

[4]Muqsith, Leda Al, and Rinto Rinto. 2019. “Strategy of the Regional Disaster Management Agency of Katingan Regency in Handling Forest and Peatland Fires in Katingan Hilir District, Katingan Regency.” Restorica: Scientific Journal of Public Administration and Communication Science 5 (2): 26–30.https://doi.org/10.33084/restorica.v5i2.1061

[5]Herry Purnomo, Dyah Puspitaloka, Besta Junandi, Lila Juniyanti, and I Wayan Susi Dharmawan. 2023. Community-Based Peatland Restoration Action in Indonesia and Southeast Asia. Center for International Forestry Research (CIFOR) & International Agroforestry (ICRAF). Bogor, Indonesia: CIFOR & ICRAF. https://doi.org/10.17528/cifor/008968 Purnomo

[6]Ardiyanto, Syaifullah Yophi, and Tengku Arif Hidayat. 2021. “Law Enforcement Patterns Against Forest and Land Burners.” PAMPAS: Journal of Criminal Law 1 (3): 79–91.https://doi.org/10.22437/pampas.v1i3.10544.

MODIS satellite imagery. All data were analyzed to evaluate the condition of existing posts and formulate strategic locations for the development of new posts, with reference to the response time standards in PU Regulation No. 25/2008 and Home Affairs Regulation No. 62/2008.The description of the techniques and outline of the research instruments that will be used are as follows:

**Table 2.1 Research Techniques and Instruments Used**

| Analysis Techniques | Aspect | Instrument Type | Respondent/Information Source |
|---|---|---|---|
| Spatial Analysis GIS Arc-GIS 10.8 | Satellite imagery for NASA MODIS Aqua/Terra Hotspot distribution from 2013 – 2023. | GIS Spatial Data SHP file | NASA MODIS Aqua/Terra |
| | NASA MODIS Rainfall 2013 - 2023 | GIS Rainfall Data SHP file | NASA MODIS Aqua/Terra |
| | Surface Temperature Data in Katingan Hilir District | GIS Temperature Data SHP file | NASA MODIS Aqua/Terra |
| | Land Cover in Katingan Hilir District | GIS Spatial Data SHP file | The Environmental Service (DLH) and the Satpolpp Fire and Rescue Division of Katingan Regency |
| | Administrative Area Map of Katingan Hilir District, Katingan Regency | GIS Spatial Data SHP file | Katingan Regency Regional Government |
| | RTRW of Katingan Hilir District, Katingan Regency | GIS Spatial Data SHP file | PUPR/PERKIMTAN/SATPOLPP Service, Fire and Rescue Division, Katingan Regency |
| | Road Map of Katingan Hilir District, Katingan Regency, Katingan Regency | GIS Spatial Data SHP file | PUPR/PERKIMTAN/SATPOLPP Service, Fire and Rescue Division, Katingan Regency |
| | Map of Large and Small Rivers and Irrigation Channels in Katingan Regency | GIS Spatial Data SHP file | PUPR/PERKIMTAN/SATPOLPP Service, Fire and Rescue Division, Katingan Regency |
| | Map of Existing Fire Department Post Locations | GIS Spatial Data SHP file | Satpolpp Fire and Rescue Division of Katingan Regency |

This study uses a quantitative approach and spatial analysis to determine the level of fire vulnerability and the optimal location of fire stations in Katingan Hilir District. The data used includes NASA MODIS satellite hotspots (2013–2023), rainfall, surface temperature, and land cover. The analysis was conducted with ArcGIS, using Kernel Density to map hotspot distribution, IDW for rainfall and temperature, and supervised classification for land cover. The vulnerability level was determined using a scoring model, while the location of fire stations was determined using Network Analyst, based on the frequency and distribution of hotspots in each region.

**Table 2.2 Fire Indicator Scoring Classification**

| VARIABLES | CHARACTERISTICS | SCORE VALUE | VULNERABILITY CLASS | SOURCE |
|---|---|---|---|---|
| Rainfall | • >4000<br>• 3000-4000<br>• 2000-3000<br>• 1000-2000<br>• <1000 | 1<br>2<br>3<br>4<br>5 | Very Vulnerable<br>Vulnerable<br>Currently<br>Not Vulnerable<br>Very Not Vulnerable | (Herdian, Boreel, and Loppies 2021) |
| Temperature | • >30oC<br>• 25oC-30oC<br>• 20oC-25oC<br>• 15oC-20oC<br>• <15oC | 1<br>2<br>3<br>4<br>5 | Very Vulnerable<br>Vulnerable<br>Currently<br>Not Vulnerable<br>Very Not Vulnerable | (Herdian, Boreel, and Loppies 2021) |
| Hotspot | • <10<br>• 10-20<br>• 30-40<br>• 40-50<br>• >50 | 1<br>2<br>3<br>4<br>5 | Very Not Vulnerable<br>Not Vulnerable<br>Currently<br>Vulnerable<br>Very Vulnerable | (Herdian, Boreel, and Loppies 2021) |
| Land Cover | • Shrubs<br>• Open Land<br>• Settlement<br>• Secondary Forest<br>• Primary Forest | 1<br>2<br>3<br>4<br>5 | Very Vulnerable<br>Vulnerable<br>Currently<br>Not Vulnerable<br>Very Not Vulnerable | (Herdian, Boreel, and Loppies 2021) |

**Source**:(Herdian, Boreel, and Loppies 2021)

This study applies weighting to assess the influence of hotspots, rainfall, surface temperature, and land cover on fire vulnerability levels in Katingan Hilir District, using a spatial map overlay technique. The vulnerability value is calculated using the formula: $K = [(0.063 \times CH) + (0.067 \times SP) + (0.240 \times TL) + (0.630 \times H)]$, which reflects the relative contribution of each factor. Fire station evaluation is conducted through descriptive analysis and Spatial Network Analyst to map 5-minute service coverage. The results are combined with overlay variables of vulnerability, road access, and existing post coverage; each variable is given a score of 1–3, and the location with the highest score is prioritized as a candidate for a new fire station.

## RESULTS AND DISCUSSION

### 1. General description

Katingan Hilir District is the administrative center of Katingan Regency, Central Kalimantan, covering an area of approximately 665.8 hectares, or 3.72% of the regency's total area. Situated in the lowlands at an elevation of approximately 22 meters above sea level, it borders several surrounding sub-districts and regencies. It also has eight villages and sub-districts whose settlements follow the Katingan River. In 2021, the population reached 40,638. Social facilities are quite comprehensive, ranging from educational institutions to healthcare services. Economically, the community is dominated by the agriculture and plantation sectors, particularly oil palm and rattan. For example, the Tenera Farmers Group in Hampalit Village has managed more than 223 hectares of RSPO-certified oil palm plantations since 2018.[7] Environmentally, the Katingan River is a major water source and influences the local hydrological system. Located in the tropical rainforest (Af) climate zone with temperatures between 23°C and 34°C, this region has high agricultural potential, but is also vulnerable to flooding and fires during the dry season. In 2023, several small fire incidents were recorded in several villages, indicating the vulnerability of forest and land fires, particularly in peatlands. The complexity of geographical conditions, climate, and land use pressures require appropriate spatial management and disaster mitigation efforts. In this context, spatial studies and

[7]Katingan Regency Central Statistics Agency, Katingan Regency Regional Statistics 2025 (Kasongan: BPS Katingan Regency, 2024)

the placement of fire stations are strategic steps to strengthen preparedness and accelerate responses for the safety of residents and environmental sustainability.

## 2. Identification of Fire-Causing Variables

### 2.1 Estimation of the Dynamic Conditions of Fire Point Distribution (Fire/Hot Spots)

A fire disaster is an event involving fire and can occur in forests, agricultural land, or settlements, with impacts that include physical and non-physical losses as well as threats to human, animal, and plant life.[8]In addition to causing environmental damage, fires also release gas emissions such as $CO_2$ and CO, which contribute to the increase in greenhouse gases. In an effort to understand and anticipate this incident, a fire vulnerability estimation model was conducted in Katingan Hilir District, covering an area of 665.8 hectares, using hotspot data from NASA's Aqua/Terra Satellite MODIS sensor and rainfall data for the 2015–2024 period. The data was analyzed using ArcGIS 10.3 software through the Kernel Density feature to map the distribution and frequency of hotspots each year. The vulnerability analysis was conducted using a scale classification approach based on the method of Herdian, Boreel, and Loppies (2021), which was then used to compile a fire vulnerability map for the area.

**Table 3.1**Fire Indicator Scoring Classification for an Area

| | | | | |
|---|---|---|---|---|
| *Hotspot* | <10 | 1 | Sangat Tidak Rawan | (Rosdiana, 2017) dimodifikasi |
| | 10 – 20 | 2 | Tidak Rawan | |
| | 30 – 40 | 3 | Sedang | |
| | 40 – 50 | 4 | Rawan | |
| | >50 | 5 | Sangat Rawan | |

**(Source:**Herdian, Boreel, and Loppies 2021)

The scoring classification in the table is used in the weighting stage to assess the influence of the NASA MODIS hotspot distribution indicator on the level of fire vulnerability in Katingan Hilir District, particularly from a natural physical perspective. The main focus of this weighting is the hotspot variable, which reflects the potential fire hazard in the field. Hotspot data for the 2015–2024 period recorded a total of 301 hotspots, with a peak of 130 hotspots in 2015, primarily between July and October. A similar spike occurred in September 2019 with 113 hotspots, but dropped drastically to 8 hotspots the following month.

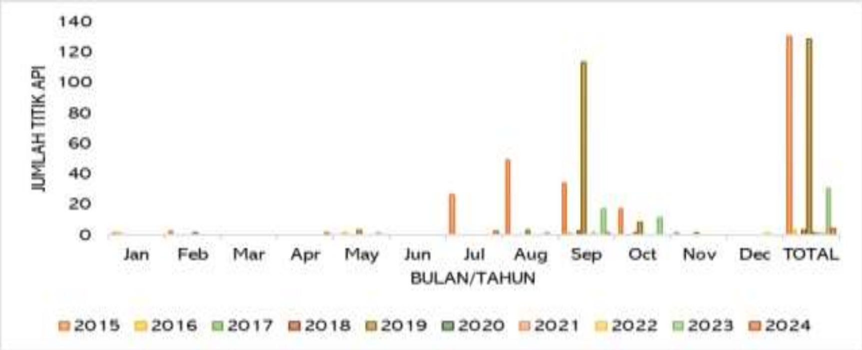
**Table 3.2** Number of NASA MODIS Hotspot Distribution in 2015 – 2024 in Katingan Hilir District

| | Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Year | Jan | Feb | Mar | Apr | May | June | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
| 1 | 2015 | 1 | 2 | | | | | 26 | 49 | 34 | 17 | 1 | | 130 |
| 2 | 2016 | 1 | | | | 1 | | | | 1 | | | | 3 |
| 3 | 2017 | | | | | | | | | | | | | 0 |
| 4 | 2018 | | | | | | | | | 2 | 1 | | | 3 |
| 5 | 2019 | | | | | 3 | | | 3 | 113 | 8 | 1 | | 128 |
| 6 | 2020 | | 1 | | | | | | | | | | | 1 |
| 7 | 2021 | | | | | | | | | 1 | | | | 1 |
| 8 | 2022 | | | | | | | | | | | | 1 | 1 |
| 9 | 2023 | | | | | 1 | | | 1 | 17 | 11 | | | 30 |
| 10 | 2024 | | | | 1 | | | 2 | | 1 | | | | 4 |
| | Average | 1.0 | 1.5 | 0.0 | 1.0 | 1.7 | 0 | 14 | 17.7 | 24.1 | 9.3 | 1 | 1 | 301.0 |

**(Source:**Analysis Results, 2025)

[8]Andre Pinem, Santosa Yulianto, and Rini Dwiastuti, "Spatial Characteristics of MODIS Hotspot Data in 2019 in Palangka Raya City, Central Kalimantan Province," Tropical Forest Journal 17, no. 1 (June 2022): 106, https://e-journal.upr.ac.id/index.php/JHT.

The table above also shows that the lowest number of hotspots, with 0, occurred in 2017, meaning there were no fires throughout that year. Meanwhile, between 2020 and 2022, there was only one hotspot per year. The average number of fires over the past 10 years has been highest in September and lowest in March and July (see Figure 3.1 below).




The hotspot distribution data from NASA MODIS was then processed and determined based on the assessment classification in Table 5.1 above. According to the results obtained, the frequency of hotspots detected in 2015 and 2019 fell into the Very Vulnerable vulnerability classification with a number of hotspots >120 points, but in the last 5 years the condition of this fire vulnerability level was in the Very Not Vulnerable to Moderate condition (See Table 3.4).

**Table 3.4** Number of Hotspots per Year from 2015 to 2024

| Year | Total Hotspot | Score | Vulnerability Level |
|---|---|---|---|
| 2015 | 130 | 5 | Very Vulnerable |
| 2016 | 3 | 1 | Not Vulnerable |
| 2017 | 0 | 1 | Not Vulnerable |
| 2018 | 3 | 1 | Not Vulnerable |
| 2019 | 128 | 5 | Very Vulnerable |
| 2020 | 1 | 1 | Not Vulnerable |
| 2021 | 1 | 1 | Not Vulnerable |
| 2022 | 1 | 1 | Not Vulnerable |
| 2023 | 30 | 3 | Currently |
| 2024 | 4 | 1 | Not Vulnerable |
| **Total** | 301 | | |
| **Average** | 30.1 | | Currently |

**(Source:**Analysis Results, 2025)


**Figure 3.2** Number of Hotspots that have appeared in the last 10 years
**Source**: Analysis Results, 2025

Based on Table 3.4 and Figure 3.2, the number and frequency of hotspots in Katingan Hilir District during the 2015–2024 period showed a fluctuating pattern with striking differences in values from year to year, totaling 301 hotspots. Referring to the classification model in Table 5.1, this area is categorized as Highly Fire Prone. The polynomial trend with Order = 3 shown in Figure 5.3 shows a pattern of hotspot occurrence in three-year intervals, which although fluctuating, tends to decrease sharply in recent years.

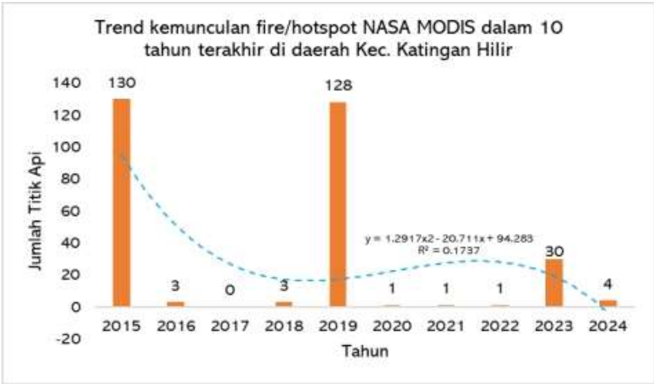



**Figure 3.3** Characteristics of NASA MODIS fire/hot spot trends in the last 10 years in the Katingan Hilir District area (Source: Analysis Results, 2025)

The distribution of hotspots in the Katingan Hilir District area appears to appear in a pattern that tends to be concentrated when plotted on a map model as seen in Figure 5.4 below. The tendency of the number of hotspots that appear in an area indicates that the distribution of the emergence of hotspots is uneven, so it can be used as a reference as an indicator of the level of vulnerability to forest fires based on the intensity of the number of hotspots that tend to be concentrated.

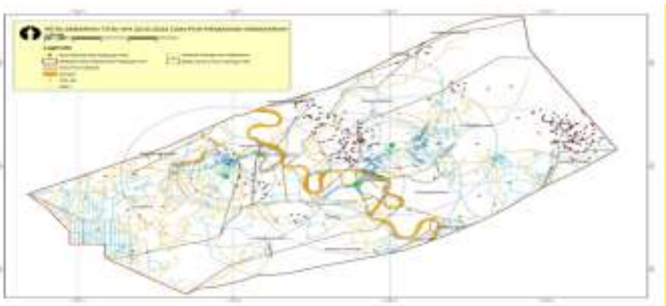


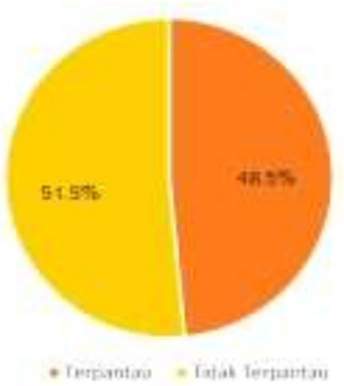
**Figure 3.4** Distribution of Fire/Hot Spots and Coverage of Fire and Rescue Post Services in Katingan Hilir District (Source: Analysis Results, 2025)

The scoring classification in the table above is used in the weighting process to measure the influence of hotspot distribution indicators from NASA MODIS data on the analysis of fire vulnerability levels in Katingan Hilir District. This weighting is applied to natural physical variables, especially fire hotspots, to determine the extent to which the distribution of hotspots contributes to the level of fire vulnerability in the area. Through this approach, grouping can be done based on the intensity of hotspot occurrences over a certain period, which then serves as the basis for vulnerability mapping.

The results of NASA MODIS fire hotspot data processing from 2015 to 2024 are shown in Table 5.2, which records a total of 301 fire hotspots with varying annual numbers. 2015 saw the highest number, at 130, with their occurrence concentrated between July and October. Subsequently, 2019 also recorded a significant spike in the number of fire hotspots, with 113 hotspots in September. However, in the following month, October 2019, the number of hotspots decreased drastically to only 8 detected hotspots. These data reflect the uneven dynamics of fire distribution each year and require further analysis to map areas with higher levels of vulnerability.

**Table 3.5** Number of Monitored and Unmonitored Fire Points based on the distance covered by the Fire Management Area by the Katingan Hilir District Fire Department Post

| | Number of Hotspots Emerging | 301 Points | |
|---|---|---|---|
| **No** | **Fire Department Post** | **Postal Coordinates** | **Hotspots Monitored Based on WMK** |
| 1 | Kereng Pangi Fire Department Post | (-1.90991, 113.29490) | 34 hotspots |
| 2 | Katunen Fire Department Post | (-1.9058, 113.38468) | 112 hotspots |
| 3 | Kereng Humbang Fire Department Post | (-1.77848, 113.28889) | 114 hotspots |
| | | | |
| | Hotspots Monitored by all Posts | | 155 Fire Points (51.5%) |
| | Total Fire Points Not Monitored by all Posts | | 146 fire points (48.5%) |




**(Source:**Analysis Results, 2025)

The distribution of NASA MODIS hotspots of 301 points over the past 10 years that occurred in the Katingan Hilir District area has not been able to be reached by three DAMKAR Posts in different areas. Based on the results of data processing and spatial analysis that have been carried out, all DAMKAR Posts in the Katingan Hilir District area were only able to reach 51.495% or 155 hotspots of the total spread of hotspots that appeared in this decade. Meanwhile, as many as 146 hotspots or ± 48.5% were not reached by the DAMKAR Post service radius. The percentage of the spread of these unreachable hotspots is more dominated in the Luwuk Kanan Village area where the area does not yet have DAMKAR Post facilities from the Katingan Regency Government.

### 2.2 Estimation of Rainfall Dynamic Conditions

Rainfall prediction based on NASA MODIS data for the Katingan Hilir District area is used to determine the condition of the amount of water falling on a flat land surface during a certain period measured in units of height (mm or inches) above the horizontal surface if there is no evaporation, run-off and infiltration. The amount of rainfall measured can indicate the thickness or height of the rainwater surface that covers the area of Katingan Hilir District that occurs annually. The NASA MODIS rainfall data used is from 2014 to 2024 as presented in Table 5.5 below.

**Table 3.6** NASA MODIS Rainfall Data
in the Katingan Hilir District area in 2014 – 2024

| | Bulan | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Tahun | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | 2014 | 182.08 | 167.28 | 242.68 | 271.50 | 267.98 | 219.56 | 65.76 | 135.87 | 86.27 | 122.61 | 328.14 | 339.52 |
| 2 | 2015 | 329.58 | 370.80 | 293.06 | 324.93 | 221.17 | 176.50 | 72.57 | 77.78 | 41.98 | 83.94 | 391.38 | 323.81 |
| 3 | 2016 | 286.85 | 382.46 | 348.98 | 340.15 | 313.66 | 254.68 | 170.83 | 115.09 | 253.65 | 328.65 | 287.49 | 250.35 |
| 4 | 2017 | 268.62 | 250.91 | 10.61 | 231.37 | 320.53 | 211.54 | 251.00 | 249.78 | 222.76 | 245.52 | 324.07 | 295.55 |
| 5 | 2018 | 207.43 | 321.57 | 359.21 | 363.83 | 286.62 | 152.10 | 110.90 | 80.54 | 100.52 | 244.69 | 322.11 | 311.02 |
| 6 | 2019 | 263.98 | 365.87 | 261.73 | 266.10 | 153.23 | 221.24 | 58.35 | 106.60 | 77.74 | 211.19 | 202.47 | 346.60 |
| 7 | 2020 | 327.87 | 324.66 | 320.29 | 373.41 | 277.78 | 230.53 | 231.39 | 174.46 | 261.08 | 297.12 | 302.27 | 186.96 |
| 8 | 2021 | 286.88 | 189.44 | 339.75 | 196.59 | 240.57 | 207.73 | 145.12 | 279.77 | 364.21 | 342.72 | 342.73 | 255.67 |
| 9 | 2022 | 266.64 | 258.11 | 272.60 | 284.58 | 293.94 | 293.92 | 273.04 | 267.38 | 350.96 | 366.87 | 281.90 | 224.37 |
| 10 | 2023 | 236.27 | 247.10 | 372.84 | 232.35 | 177.82 | 198.32 | 194.64 | 123.60 | 141.54 | 183.11 | 278.79 | 306.14 |
| 11 | 2024 | 275 | 262.111 | 342.65 | 254.34 | 224.32 | 234 | 234.75 | 222.49 | 300.24 | 333.15 | 268.83 | 241.96 |
| | Rerata | 274.91 | 297.30 | 292.17 | 286.76 | 250.96 | 218.06 | 174.26 | 169.75 | 211.47 | 263.70 | 300.20 | 274.24 |

(Source: Analysis Results, 2025)

The figure above shows that average rainfall data around Katingan Hilir District from 2014 to 2024 shows that the period with the lowest rainfall generally occurs from July to September (averaging only around 174.26 mm, 169.75 mm, and 211.47 mm, respectively). This low rainfall triggers dry conditions and facilitates the occurrence of land and forest fires because fuel (dry plants or litter) is more flammable and spreads more easily. In Figure 3.5 below, it can be seen that there has been a decreasing trend in the amount of rainfall every year for the last 10 years.

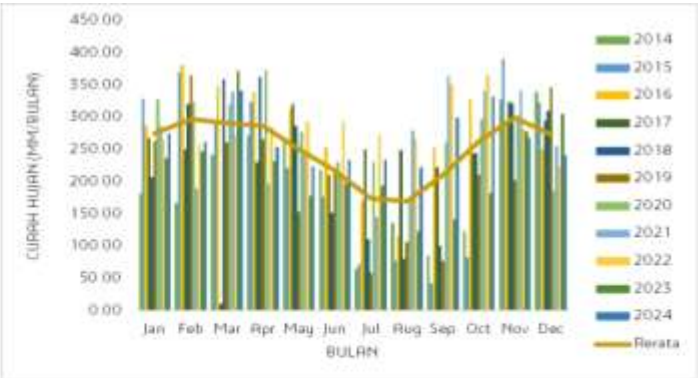



**Figure 3.5** Rainfall graph trend based on NASA MODIS monitoring data from 2014-2024 in Katingan Hilir District (Source: Analysis Results, 2025)

Rainfall conditions in a region can determine the humidity level and water content of land cover and areas that influence fire vulnerability, as stated by (Herdian, Boreel, and Loppies 2021). Rainfall conditions in the last 10 years (201-2024) received by the Katingan Hilir District area can provide an overview of the average monthly rainfall value, the average annual rainfall value, the total annual and monthly rainfall value, and the average rainfall value per 10 years, as seen in Table 5.6 below.

**Table 3.7** Average Rainfall Value in Katingan Hilir District
based on the period 2014 – 2024

| | Bulan | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Tahun | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Rerata | Total |
| 1 | 2014 | 182.08 | 167.28 | 242.68 | 271.50 | 267.98 | 219.56 | 65.76 | 135.87 | 86.27 | 122.61 | 328.14 | 339.52 | 202.44 | 2429.26 |
| 2 | 2015 | 329.58 | 370.80 | 293.06 | 324.93 | 221.17 | 176.50 | 72.57 | 77.78 | 41.98 | 83.94 | 391.38 | 323.81 | 225.62 | 2707.50 |
| 3 | 2016 | 286.85 | 382.46 | 348.98 | 340.15 | 313.66 | 254.68 | 170.83 | 115.09 | 253.65 | 328.65 | 287.49 | 250.35 | 277.73 | 3332.81 |
| 4 | 2017 | 268.62 | 250.91 | 10.61 | 231.37 | 320.53 | 211.54 | 251.00 | 249.78 | 222.76 | 245.52 | 324.07 | 295.55 | 240.19 | 2882.25 |
| 5 | 2018 | 207.43 | 321.57 | 359.21 | 363.83 | 286.62 | 152.10 | 110.90 | 80.54 | 100.52 | 244.69 | 322.11 | 311.02 | 238.38 | 2860.54 |
| 6 | 2019 | 263.98 | 365.87 | 261.73 | 266.10 | 153.23 | 221.24 | 58.35 | 106.60 | 77.74 | 211.19 | 202.47 | 346.60 | 211.26 | 2535.11 |
| 7 | 2020 | 327.87 | 324.66 | 320.29 | 373.41 | 277.78 | 230.53 | 231.39 | 174.46 | 261.08 | 297.12 | 302.27 | 186.96 | 275.65 | 3307.81 |
| 8 | 2021 | 286.88 | 189.44 | 339.75 | 196.59 | 240.57 | 207.73 | 145.12 | 279.77 | 364.21 | 342.72 | 342.73 | 255.67 | 265.93 | 3191.17 |
| 9 | 2022 | 266.64 | 258.11 | 272.60 | 284.58 | 293.94 | 293.92 | 273.04 | 267.38 | 350.96 | 366.87 | 281.90 | 224.37 | 286.19 | 3434.32 |
| 10 | 2023 | 236.27 | 247.10 | 372.84 | 232.35 | 177.82 | 198.32 | 194.64 | 123.60 | 141.54 | 183.11 | 278.79 | 306.14 | 224.38 | 2692.52 |
| 11 | 2024 | 275 | 262.111 | 342.65 | 254.34 | 224.32 | 234 | 234.75 | 222.49 | 300.24 | 333.15 | 268.83 | 241.96 | 266.16 | 3193.86 |
| | Rerata | 274.91 | 297.30 | 292.17 | 286.76 | 250.96 | 218.06 | 174.26 | 169.75 | 211.47 | 263.70 | 300.20 | 274.24 | | |
| | Total | 2931.17 | 3140.30 | 3164.38 | 3139.15 | 2777.62 | 2400.20 | 1808.34 | 1833.36 | 2200.95 | 2759.56 | 3330.17 | 3081.95 | | |
| | Curah Hujan Rerata dalam 10 tahun = | | | | 2960.7 | | | | | | | | | | |
| | Total Curah Hujan dalam 10 tahun = | | | | 32567.15 | | | | | | | | | | |

(Source: Analysis Results, 2025)

The table above shows that the highest total rainfall from 2014 to 2024 occurs between November and April each year (>2900 mm/year). The lowest rainfall values range from July to September, ranging from 1808.34 to 2200.95 mm/year. Over the past 10 years, the lowest total rainfall occurred in 2014, 2015, and 2019, with values of 2429.26 mm/year, 2707.50 mm/year, and 2535.11 mm/year, respectively. The highest total annual rainfall occurred in 2022, with a value of 3434.32 mm/year, surpassing 2016's 3332.81 mm/year. Furthermore, to determine the level of fire vulnerability based on annual rainfall conditions, an analysis is necessary based on the rainfall condition weighting, which refers to the rainfall data in the table above. This is to see how rainfall conditions in the Katingan Hilir District can describe the condition of land cover, as seen from the humidity level and wetness of the land. The following is a basic table of weighted classifications for rainfall used to determine rainfall scores at the study location:

**Table 3.8** Rainfall Classification and Score at the Research Location

| Variables | Characteristics of Values | Score | Vulnerability Level |
|---|---|---|---|
| RAINFALL | <1000 | 1 | Very Vulnerable |
| | 1000 - 2000 | 2 | Vulnerable |
| | 2000 - 3000 | 3 | Currently |
| | 3000 - 4000 | 4 | Not Vulnerable |
| | >4000 | 5 | Very Not Vulnerable |

(Source: Analysis, 2025)

Based on the results of predictions and analysis of rainfall conditions from NASA MODIS data in the Katingan Hilir District area, it shows relatively moderate rainfall figures and is not prone to the threat of fires that could occur during the last 10 years as seen in Table 3.9 below.

**Table 3.9** Prediction results of the level of rainfall vulnerability to the possibility of forest fires

| Year | Total CH | Score | Vulnerability Level |
|---|---|---|---|
| 2015 | 2707.5 | 3 | Currently |
| 2016 | 3332.81 | 4 | Not Vulnerable |
| 2017 | 2882.25 | 3 | Currently |
| 2018 | 2860.54 | 3 | Currently |
| 2019 | 2535.11 | 3 | Currently |
| 2020 | 3307.81 | 4 | Not Vulnerable |
| 2021 | 3191.17 | 4 | Not Vulnerable |
| 2022 | 3434.32 | 4 | Not Vulnerable |
| 2023 | 2692.52 | 3 | Currently |
| 2024 | 3193.86 | 4 | Not Vulnerable |
| **Total** | 30138 | | |
| **Average** | 3013.789 | | Not Vulnerable |

(Source: Analysis, 2025)

The level of rainfall vulnerability in Katingan Hilir District is generally categorized as Moderate to Not Vulnerable, with rainfall above 3000 mm/year indicating a low fire risk. During 2015, 2017–2019, and 2023, rainfall was recorded below this threshold, thus categorizing it as Moderately Vulnerable. The distribution of rainfall is visualized in the overlay maps for 2015–2024 (Figures 5.6 and 5.7), which show the spatial pattern of rainfall in the region.

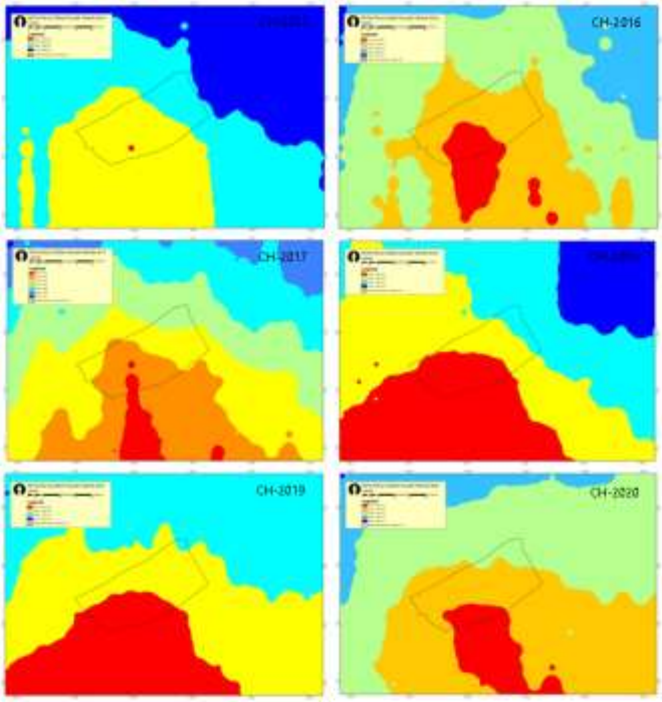



**Figure 3.6** Rainfall Map 2015 - 2020 in Katingan Hilir District
(Source: Analysis Results, 2025)

In 2016, rainfall in Katingan Hilir District increased compared to the previous year, with a distribution of 3000–3400 mm/year covering approximately 90% of the area, including Tumbang Liting, Tewang Kadamba, and parts of Hampalit and Kasongan Baru. This condition was categorized as "Not Prone" to fire. However, from 2017 to 2019, rainfall decreased to around 2000–3000 mm/year, especially in the villages of Hampangen, Kasongan Lama, Tumbang Liting, Kereng Pangi, and Hampalit, so it was included in the "Moderate Prone" category.

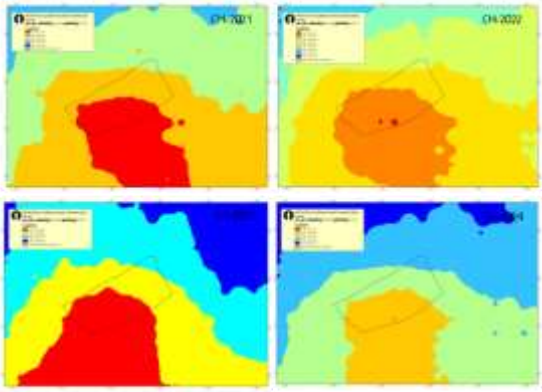


**Figure 3.7** Rainfall Map 2021 - 2024 in Katingan Hilir District
(Source: Analysis Results, 2025)

In 2021 and 2022, Katingan Hilir District experienced an increase in rainfall of 3,200–3,600 mm/year, which, according to Table 5.7, falls into the “Not Prone” category for fires. However, a significant decrease occurred in 2023 and 2024. In 2023, most areas received a maximum rainfall of 2,600–2,800 mm/year, particularly in sub-districts such as Hampalit and Kasongan Baru. 2024 showed a slight increase, but rainfall remained in the range of 3,000–3,200 mm/year. Consequently, these two years were categorized as “Moderately Prone” to fire risk.

### 2.3 Estimation of Land Cover Dynamic Conditions

Land cover in Katingan Hilir District encompasses various types, including forests, plantations, settlements, swamps, agriculture, and water bodies, each of which is scored based on its vegetation or function. This data was obtained from the Katingan Regency Environmental Agency through interpretation of Sipongi satellite imagery. All land cover classes are classified into a scoring table for fire vulnerability analysis.

| No | Land Cover Types | Score | Vulnerability Class |
|---|---|---|---|
| 1 | Bushes/Shrubs, Dry Land Agriculture mixed with Bushes, Settlements/Villages | 1 | Very Vulnerable |
| 2 | Swamp Bushes/Shrubs, Dry Land Agriculture, Plantations | 2 | Vulnerable |
| 3 | Secondary Swamp Forest | 3 | Currently |
| 4 | Mining, Open Land | 4 | Not Vulnerable |
| 5 | Swamp, Body of Water, Lake | 5 | Very Not Vulnerable |

(Source: Analysis Results, 2025)

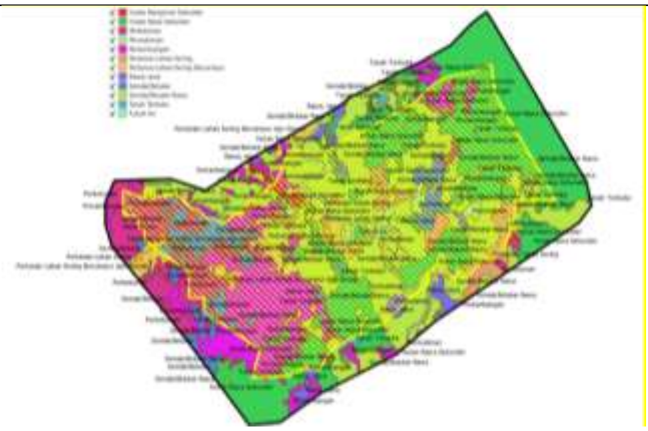


**Figure 3.8** Land Cover Map 2024 in Katingan Hilir District
(Source: Analysis Results, 2025)

According to Christiawan (2018) in Herdian et al. (2021), significant and dynamic changes in land cover types can be an important indicator in monitoring forest and land fire vulnerability index information. These changes, both in terms of area and spatial function, also influence the level of fire potential. The results of land cover data processing in Katingan Hilir sub-district over 10 years (2015-2024) can be seen in the table below:

**Table 3.10** Land Cover Classification in Katingan Hilir District 2015-2024

| No | Land Cover Types | Area (Ha) | % |
|---|---|---|---|
| 1 | Bushes/Shrubs, Dry Land Agriculture mixed with Bushes, Settlements/Villages | 7442.50 | 11.79% |
| 2 | Swamp Bushes/Shrubs, Dry Land Agriculture, Plantations | 25540.60 | 40.47% |
| 3 | Secondary Swamp Forest | 16630.9 | 26.35% |
| 4 | Mining, Open Land | 10800.3 | 17.11% |
| 5 | Swamp, Body of Water, Lake | 2692.7 | 4.27% |
| | **TOTAL** | **63107** | **100%** |

Land cover analysis in Katingan Hilir District from 2015–2024 shows that Swamp Shrub/Scrub, Dryland Agriculture, and Plantations dominate with an area of 25,540.60 Ha (40.47%), followed by Secondary Swamp Forest (26.35%) and Mining and Open Land (17.11%). The smallest areas are found in Shrub/Scrub, Mixed Shrub Agriculture, Settlements, Swamps/Lakes, and Water Bodies. These changes are visualized in Figures 3.8 and 3.10 using ArcGIS. The level of vulnerability based on area or percentage of the area is shown in the following table:

**Table 3.11** Land Cover Vulnerability Classification in Katingan Hilir District 2015-2024 based on land cover area (%)

| No | Land Cover Types | Area (Ha) | % | Score | Vulnerability Class |
|---|---|---|---|---|---|
| 1 | Swamp Bushes/Shrubs, Dry Land Agriculture, Plantations | 25540.60 | 40.47% | 5 | Vulnerable |
| 2 | Secondary Swamp Forest | 16630.9 | 26.35% | 4 | Currently |
| 3 | Mining, Open Land | 10800.3 | 17.11% | 3 | Not Vulnerable |
| 4 | Bushes/Shrubs, Dry Land Agriculture mixed with Bushes, Settlements/Villages | 7442.50 | 11.79% | 2 | Very Vulnerable |
| 5 | Swamp, Body of Water, Lake | 2692.7 | 4.27% | 1 | Very Not Vulnerable |
| | **TOTAL** | **63107** | **100%** | | |

(Source: Analysis Results, 2025)

However, if the criteria for the level of vulnerability of land cover to potential fires are based on the type of land cover as used by Herdian A, et al 2021, then the classification or class of vulnerability in the Katingan Hilir District area[9]can be seen in the following table:

**Table 3.12** Land Cover Vulnerability Classification in Katingan Hilir District 2015-2024

| No | Land Cover Types | Area (Ha) | % | Score | Vulnerability Class |
|---|---|---|---|---|---|
| 1 | Bushes/Shrubs, Dry Land Agriculture mixed with Bushes, Settlements/Villages | 7442.50 | 11.79% | 1 | Very Vulnerable |
| 2 | Swamp Bushes/Shrubs, Dry Land Agriculture, Plantations | 25540.60 | 40.47% | 2 | Vulnerable |
| 3 | Secondary Swamp Forest | 16630.9 | 26.35% | 3 | Currently |
| 4 | Mining, Open Land | 10800.3 | 17.11% | 4 | Not Vulnerable |
| 5 | Swamp, Body of Water, Lake | 2692.7 | 4.27% | 5 | Very Not Vulnerable |
| | **TOTAL** | **63107.00** | **100%** | | |

Based on Table 5.12, land cover classified as "Very Vulnerable" (score 1) includes Shrubs/Crudice, Dryland Agriculture mixed with Shrubs, and Settlements with an area of 11.79% or 7,442.50 Ha. Meanwhile, the "Vulnerable" category (score 2) includes Swamp Shrubs/Crudice, Dryland Agriculture, and Plantations covering an area of 25,540.60 Ha (40.47%). This analysis shows that the "Vulnerable" category dominates the potential fire vulnerability based on the type and area of land cover in Katingan Hilir District.

**Tutupan Lahan Berpotensi Kebakaran = 7442.50 Ha (11.79%) + luas 25540.60 Ha (40.47%)**
**= 32983.1 Ha (52.26%)**

[9]Herdian, A., Boreel, A., & Loppies, R. (2021). Forest and Land Fire Vulnerability Level Using Geographic Information Systems (GIS) in Ambon City (Case Study in the South Leitimur Peninsula). Journal of Small Island Forests, 5(1), 1–13.https://doi.org/10.30598/jhppk.2021.5.1.1

**Figure 3.9** Map of land cover dynamics 2015-2018 in the sub-district area

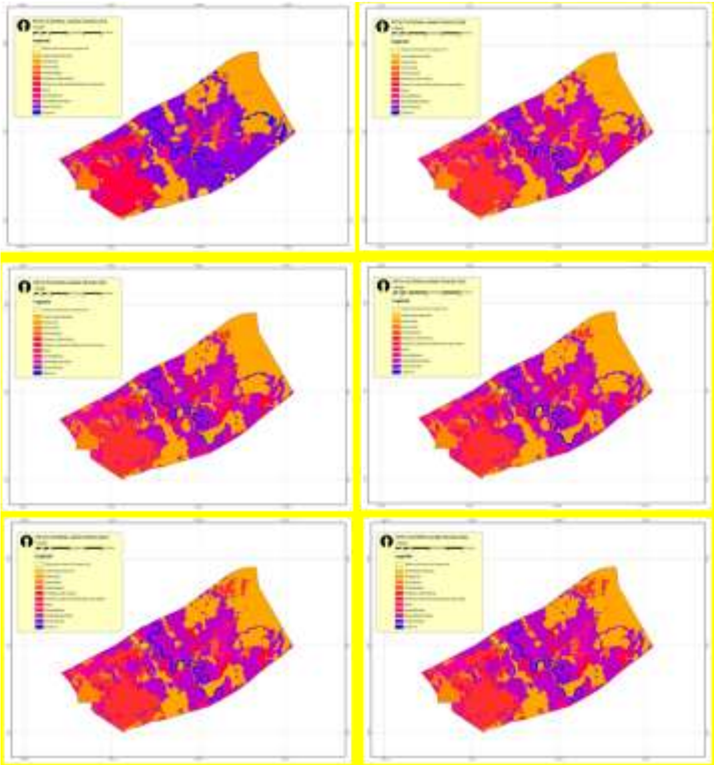


**Figure 3.10** Map of land cover change dynamics 2019-2024
in the Katingan Hilir District area
(Source: Analysis Results, 2025)

### 3. Prediction of Fire Risk Conditions

In making predictions regarding the level of fire vulnerability based on parameters from NASA MODIS Hotspot data, NASA Rainfall Data, and Land Cover Data from 2015 to 2024 in the Katingan Hilir District area. The vulnerability modeling in this case involves the 3 indicators above which begins with determining the weighting of the results of NASA MODIS satellite image processing analysis for Hotspot data, rainfall data, and land cover of the Katingan Ministry of Environment and Forestry. The weighting value is used to determine the level of fire vulnerability in the Katingan Hilir District area with an overlay model for 10-year data series from Hotspot data, Rainfall and Land Cover using ArcGIS software.

$$K = [(0.063*CH) + (0.240*TL) + (0.697*H)]$$

To determine the level of fire vulnerability based on the 3 variables of Hotspot, Rainfall, and Land Cover, the data is processed using the Fire Susceptibility Classification equation according to Aldi Herdian, et al., 2021, namely:

Where:
**K** = Fire Vulnerability Level
**CH** = NASA MODIS Rainfall Figures 2015 – 2024
**TL**= Land Cover Figures 2015-2024
**H** = NASA MODIS Hotspot Numbers 2015 – 2024

With the following fire vulnerability classification table:

**Table 3.13** Fire Hazard Classification
**(Source**: Analysis, 2025)

| No | Skor | Tingkat Kerawanan (Nilai K) |
|---|---|---|
| 1 | <183 | Sangat Tidak Rawan |
| 2 | 184 – 225 | Tidak Rawan |
| 3 | 226 - 239 | Sedang |
| 4 | 240 – 260 | Rawan |
| 5 | >261 | Sangat Rawan |

**Table 3.14** Weighting for each fire vulnerability indicator
(Source: Analysis, 2025)

| No. | Indicator | Weight (%) |
|---|---|---|
| 1 | *Hotspot* | 67.90% |
| 2 | Rainfall | 24.00% |
| 3 | Land Cover | 6.30% |
| | | Total = 100% |

The results of satellite image analysis and fire vulnerability classification for 2015–2024 in Katingan Hilir District produced a new vulnerability map using NASA hotspot data overlay techniques, rainfall, and land cover. The map (Figure 3.11) shows two vulnerability zones: “Medium” around a 7.5 km radius from the Kereng Humbang Fire and Rescue Post and “High” in the Hampangen to Luwuk Kanan area, which has not been reached by fire and rescue services despite having a larger area and greater risk.

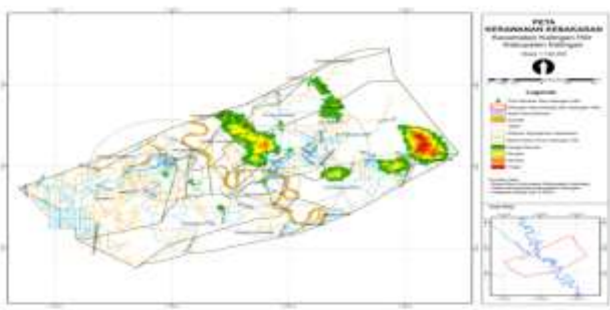


**Figure 3.11** Fire hazard map in Katingan Hilir District
**(Source:**Analysis Results, 2025)

Spatial analysis shows that the border area of Katingan Hilir and Tasik Payawan Districts, particularly Hampangen Village, has a fire vulnerability rating of "Medium" to "High." This is influenced by the distribution of hotspots (48.5% or 146 hotspots), land cover dominated by shrubs and dryland agriculture, and low-moderate rainfall (2000–3000 mm/year). This area is not accessible to all fire stations, and field validation (Figure 3.12) confirms the dominance of fire-prone land.


**Figure 3.12** Land cover conditions in the form of dry bushes/brush in the Hampangen Village area, Katingan Hilir District (Source: Analysis Results, 2025)

In addition, based on NASA satellite imagery results, the concentration of hotspots, especially around Hampangen village, reached 113 hotspots or around 77.40% of the total number of hotspots (146 hotspots) that appeared outside the service coverage of all DAMKAR posts in Katingan Hilir District. This hotspot percentage figure also supports the strong level of fire vulnerability in the Hampangen Village area in the last 10 years from 2015 to 2024. The distribution of the number of hotspots in the area in question can be seen in the image below:

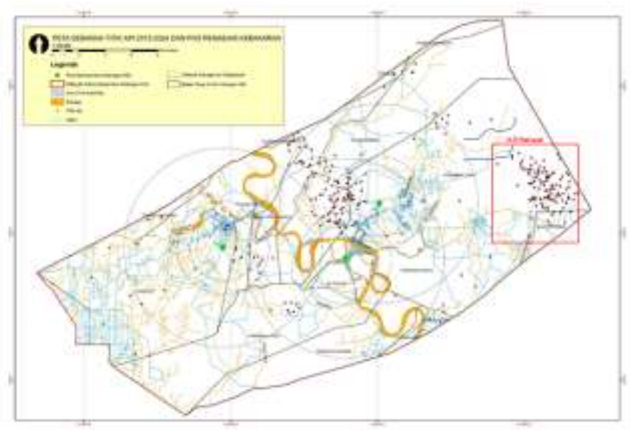


**Figure 3.13** Number of hotspots in the Hampangen Village area, Katingan Hilir District
**(Source:**Analysis Results, 2025)

4. **Development and Addition of New Fire Department Posts Based on Fire Spot Distribution & Rainfall**

The location of a fire station must take into account response speed, traffic conditions, and the road network. With a target response time of 15 minutes, the ideal distance from the station to the service area is 3–5 km, with a maximum distance of 7.5 km as per Minister of Public Works Decree No. 11/2000. If fires frequently occur outside this range, additional fire stations should be considered to ensure optimal service.

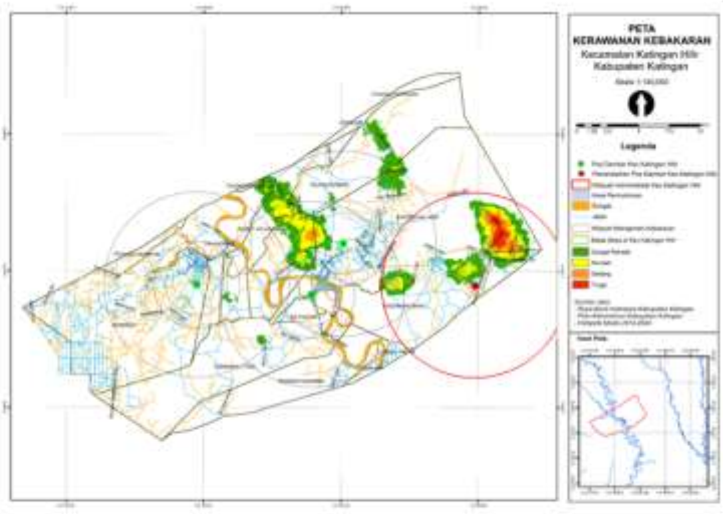



**Figure 3.14** Planned Location of New Fire and Rescue Service Post in Hampangen Village, Katingan Hilir District (Source: Analysis Results, 2025)

Figure 3.14 shows the planned addition of a firefighting post in Hampangen Village, an area with high vulnerability over the past 10 years. The new post (1°54'39"S–113°29'50"E) is strategically located near the Kasongan–Palangka Raya main road, with access to roads, electricity, and water. With a service radius of 7.5 km, this post is estimated to cover 50% of the vulnerable area in Katingan Hilir, although some of its coverage falls within the Tasik Payawan area.

## Conclusion and Suggestions

Over the past ten years, the fire vulnerability level in Katingan Hilir District has been classified as "Moderate," with peak hotspots occurring in 2015 (130 hotspots) and 2019 (128 hotspots). Of the total 301 hotspots, only 51.5% are accessible by the three existing Fire and Rescue (DAMKAR) posts, while 48.5%, particularly in Hampangen Village and the Tasik Payawan border, are not yet covered. Average rainfall below 3,400 mm/year indicates a vulnerability of "Not Vulnerable" to "Moderate," while land cover is dominated by Swamp Shrubs/Scrubs, Dryland Agriculture, and Plantations (40.47%) and Secondary Swamp Forest (26.25%) which are classified as "Vulnerable" to "Moderate." Based on the combined analysis of hotspots, rainfall, and land cover, it is recommended to add a Fire and Rescue Post in Hampangen Village (1°54'39"S–113°29'50"E) with a radius of 7.5 km. This location is considered strategic because it is supported by road access, electricity, and water sources, and is able to meet response times under 15 minutes according to Ministerial Regulation of Public Works No. 25/2008. For future development, it is recommended to add Land Surface Temperature parameters and consider social, cultural, and regional policy factors so that fire management is more effective and targeted.

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