Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 20, No 3, 2023, 691-703
Article available at homepage presipitasi

Regional Case Study

Hotspot Distribution Analysis as Forest and Land Fire Indicators in the New National Capital City (IKN)

Rosalina Kumalawati[1]*, Astinana Yuliarti[2], Jany Tri Raharjo[3], Rijanta[4], Ari Susanti[5], Erlis Saputra[4], Puput Wahyu Budiman[7], Rahmat Aris Pratomo[8], Karnanto Hendra Murliawan[9], Wisnu Putra Danarto[1], Ghinia Anastasia Muhtar[1], Rizki Nurita Anggraini[1]

[1]Department of Geography, Faculty of Social and Political Sciences, Universitas Lambung Mangkurat 70123, Indonesia
[2]Department of Communication Science, Faculty of Social and Political Sciences, Universitas Lambung Mangkurat ,70123, Indonesia
[3]Peatland and Mangrove Restoration Agency of Republic of Indonesia
[4]Faculty of Geography, Universitas Gajah Mada, 55281, Indonesia
[5]Faculty of Forestry, Universitas Gajah Mada ,55281, Indonesia
[7]Badan Penelitian dan Pengembangan Daerah Provinsi Kalimantan Timur, Indonesia
[8]Departemen of Civil and Architecture Engineering, Institut Teknologi Kalimantan, Indonesia
[9]Ministry of Agrarian & Spatial Plan/National Land Agency, 70231, Indonesia
*Corresponding Author, email: rosalina.kumalawati@ulm.ac.id

Abstract

East Kalimantan Province is planned as the new national capital city (IKN). Forest and land fires occur regularly every year and their frequency is increasing, especially during the dry season. This research uses secondary data, namely hotspot data. Hotspot data was obtained from the results of the 2012-2022 S-NPP VIIRS image recording. Data analysis in this study used descriptive and statistical analysis. The results of processing and analysis of the distribution of hotspots are overlaid with administrative maps so that the distribution of hotspots in each district in the study area can be identified. The results of the study show that hotspots distribution from the 2012-2022 S-NPP VIIRS image recording in East Kalimantan Province is varies quite a bit in each district. The highest hotspots distribution is in Kutai Kartanegara Regency and the lowest is in Mahakam Ulu and Penajam Paser Utara Regency. The higher number of hotspots is the higher incidence for forest and land fires. The distribution of hotspots needs to be known because it can be a form of early detection and fire mitigation so that the negative impact of fires can be minimized.

Keywords: Hotspot distribution; S-NPP VIIRS; indicators; forest; land fires.

1. Introduction

Fires are disasters and serious problems that routinely occur every year in various countries including Indonesia (Kumalawati et al, 2018 & Kumalawati et al, 2023). Fires in Indonesia also occur frequently in Kalimantan including East Kalimantan especially every dry season (Bowen et al, 2001; Wibowo, 2019). Fires increase every dry season and with land clearing (Kumalawati et al, 2023; Sastry, 2002; Stole, 2003) and forests burning (Kumalawati et al, 2020). The impact of forest and land fires is quite numerous and very detrimental because it can cause damage to the environment and ecosystem and affect social, economic, transportation, and health conditions (L.Tacconi, 2016; AJ Wulan et al, 2016; R.Ajin et al, 2016; Ikhwan, 2016; RP Nugraha et al, 2019; Rozi et al 2020; AA Fitriani et al, 2021).

Forest and land fires can be identified by looking at the distribution of hotspots (Saharjo et al, 2021). Hotspots are obtained from recording SNPP VIIRS satellite images as an approach for early detection of fires, where the greater the number of hotspots, the greater the potential for fire (Kumalawati et al, 2021). Forest and land fire detection is a very important solution to prevent and control fires (Trestiyan et al, 2022) . Fire detection in addition to looking at the number of hotspots also by looking at the level of hotspot confidence and hotspot temperature provisions of ≥330°K or ≥ 56.85°C for hotspots recorded by MODIS images (Giglio et al, 2003).

Kalimantan Island is one of places which forest and land fires happen every year due to the large amount of oil palm and peatland that causes fires on Kalimantan Island. In research that has been conducted in South Kalimantan Province from 2012 to 2022, there have been forest and land fires The number of hotspots from 2012-2021 goes up and down every year, sometimes up and sometimes down, the decrease that occurs is caused by many factors such as weather factors or rainfall (Kumalawati et al, 2021). The highest hotspot in 2015. East Kalimantan Province as the new national capital city, requires analysis of the spatial distribution of hotspots in order to carry out preventive management of forest and land fires.

The environmental issue is one of the reasons why the new capital city has been moved to East Kalimantan Province, such as earth quake, over population and fresh water vulnerability. But, according to the results of the above presentation, Kalimantan Island is a subscription to land fires almost every year. The government itself has determined that development in IKN must have the concept of a forest city. Forest City is development dimension that pays attention to the environmental side in social, economic, and cultural fields. Assessing the potential disaster is one approach that can realize forest city because each area will be developed based on the function or potential it already has. Therefore, it is very necessary to conduct research related to fire hotspot The purpose of the study was to determine and analyze the distribution of hotspots as an indicator of the incidence of forest and land fires in the location of the new national capital. The distribution of hotspots is known to be an indicator of the occurrence of forest and land fires so that negative impacts can be minimized due to fires.

2. Literature Review

Forest and land fires in Indonesia are a serious concern in the world, both domestically, nationally, and internationally because they have a considerable negative impact (Kumalwati et al, 2023; Maranatha et al, 2020; Marlina et al, 2020; Nisa, 2020; Wibowo et al, 2021). Fires are inappropriately caused by land clearing, namely by burning forests and land causing disasters (Utami et al, 2017). Forest and land fires greatly affect various sectors, both problems, transportation barriers, ecological damage, and economic decline (Marlina et al, 2020; Edi et al,2020; Uddin et al, 2021).

Forest and land fires in Indonesia are regional and global disasters, these disasters occur almost every year in East Kalimantan Province (Syarifa et al, 2020). East Kalimantan Province is the construction site of the new state capital. The location of the new state capital has a high potential for forest and land fires so it needs serious attention. Forest and land fires are natural disasters (Wibowo et al, 2020), which often occur every dry season (Yusuf et al, 2019; Saputro et al, 2021; Dicelebica et al, 2020) and are the cause of the annual environmental crisis (Karo,2020). Forest and land fires are also an annual problem and disaster because they occur annually (Aldi,2021; Goma et al, 2020). Forest and land fires occur due to 2 (two) main factors, namely natural factors (El-Nino which causes long droughts) and uncontrolled human activity factors (land clearing by burning) (Rosalina et al, 2019; Agustiar et al, 2020; Ardiansah et al, 2020; Almegi et al, 2022).

Forest and land fires can be detected from the number of hotspots and confidence levels (Indradjad et al, 209; Aflahah et al, 2019). The number of hotspots and high confidence levels can be indicators of fire events so as early detection. Early detection in efforts to prevent and control forest and land fires can be known through hotspot distribution information obtained from remote sensing data in the form of satellite data (Almegi et al, 2022; Nata, 2020; Imansyah, 2021). Satellite images that record hotspots used in research are S-NPP VIIRS (Indradjad et al, 2019; Purbahapsari et al 2022). Hotspots in large numbers and ongoing continuously are indicators to detect forest and land fires (Adam, 2020; Fitria, 2023; Jihar et al, 2023) (see Figure 1). Early detection of forest and land fires is urgently needed to minimize the greater negative impacts resulting from fires.

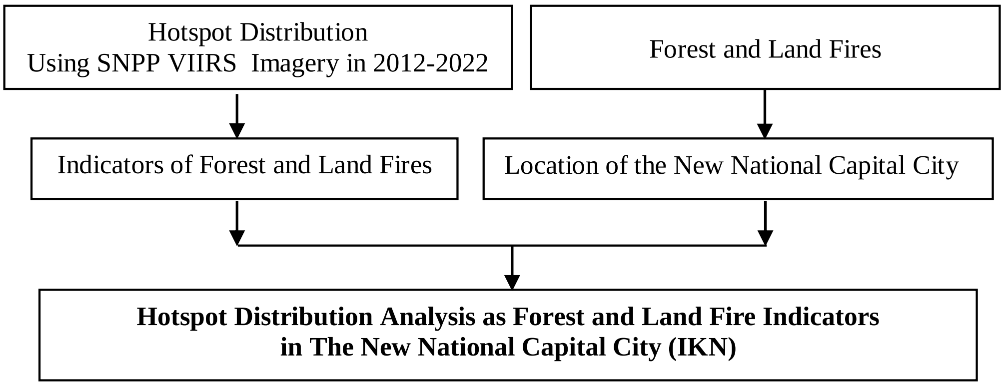


Figure 1. Hotspot distribution analysis as forest and land fire indicators in the new national capital city (IKN)

VIIRS stands for Visible and Infrared Imaging Radiometer Suite. VIIRS is one of the sensors carried by the Suomi-NPP (National Polar-orbiting Operational Environmental Satellite System Preparatory Project) which was launched on October 28, 2011. The VIIRS sensor consists of over sixteen channels of moderate resolution (M-Bands) ranging from M1 to M16, one channel Day/Night Band (DNB), and five high-resolution imagery channels (I-Bands) namely I1 to I5. The VIIRS sensor has similarities with previous satellites, such as VHRR, OLS, MODIS, SeaWiFS. The VIIRS sensor consists of 22 channels with a spectral band coverage of 412 nm up to 12 μm, imagery channels with a nadir resolution of approx. 375 meters in five channels. The coverage area of one image is 3000 km, with spatial resolution: 370/740 m. Information regarding the technical characteristics of the VIIRS sensor which consists of bandwidth, reflected r, age, and band explanation is shown in Table 1.

Table 1. Band and reflected range VIIRS

Band	Reflected Range (μm)	Band Explanation
I1	0.6 - 0.68	Visible/Reflective
I2	0.85 - 0.88	Near Infrared
I3	1.58 - 1.64	Shortwave Infrared
I4	3.55 - 3.93	Medium-wave Infrared
I5	10.5 - 12.4	Longwave Infrared
M1	0.402 - 0.422	Visible/Reflective
M2	0.436 - 0.454	Visible/Reflective
M3	0.478 - 0.488	Visible/Reflective
M4	0.545 - 0.565	Visible/Reflective
M5	0.662 - 0.682	Near Infrared
M6	0.739 - 0.754	Near Infrared
M7	0.846 - 0.885	Shortwave Infrared
M8	1.23 - 1.25	Shortwave Infrared
M9	1.371 - 1.386	Shortwave Infrared
M10	1.58 - 1.64	Shortwave Infrared

Band	Reflected Range (μm)	Band Explanation
M11	2.23 - 2.28	Medium-wave Infrared
M12	3.61 - 3.79	Medium-wave Infrared
M13	3.97 - 4.13	Longwave Infrared
M14	8.4 - 8.7	Longwave Infrared
M15	10.26 - 11.26	Longwave Infrared
M16	11.54 - 12.49	Day/Night
DNB	0.5 - 0.9	Visible/Reflective

In addition to VIIRS imagery, several imageries have been used to detect the distribution of forest and land fires or hotspots including TERRA, and AQUA with MODIS (Moderate Resolution Imaging Spectroradiometer) sensors. Hotspots are obtained from MODIS data using global algorithms developed by NASA and software implementations using software developed by Wisconsin University. The fire detection method from MODIS data, both TERRA and AQUA, produces more value than data derived from NOAA satellites, while as validation for low-resolution data (limitation of band or pixel size in imagery), it can also use Landsat 8 data with OLI data (Muhammad and Riki, 2022). Hotspot information from MODIS and VIIRS satellite data can detect forest fires in 49% of events with a confidence level of 30% to 80% (Andy et al, 2019)

3. Method

The research was conducted in East Kalimantan Province, which is the location of the new state capital. The study population was all districts in East Kalimantan that found hotspots. The number of populations is equal to the number of samples. The study used secondary data, namely hotspot data from the results of VIIRS S-NPP image recording for 2012-2022 at high, medium, and low confidence levels. Hotspot data is processed and analyzed using a Geographic Information System (GIS using Arc-GIS software), while Microsoft Office is for tabulation and graphic processing (Saharjo et al, 2021; Trestiyan et al, 2020; Rosalina et all, 2021). This research use descriptive analysis and statistical analysis as we as spatial analysis (Saharjo et al, 2021, Rosalina et all, 2021; Sari et al, 2020; Arisman, 2020)]. Descriptive statistics is a statistical analysis that provides a general picture of the characteristics of each research variant (Rosalina et all, 2021). The results of processing and analyzing the distribution of hotspots are overlaid with administrative maps so that the distribution of hotspots in each district in the research area can be known. Areas with a high number of hotspots are indicators of high incidence and land fires in these areas (see Figure 2). In determining the high, medium and low level categories of forest and land fires used the formula:

$$\text{forest and land fires level} = \frac{\text{maximum values of hotspots-minimum values hotspots}}{3} \quad (1)$$

$$\text{Low level} = \text{minimum values} + \text{forest and land fires level} \quad (2)$$

$$\text{Medium level} = \text{Low level} + \text{forest and land fires level} \quad (3)$$

$$\text{High level} = \text{Medium level} + \text{forest and land fires level or more than medium level} \quad (4)$$

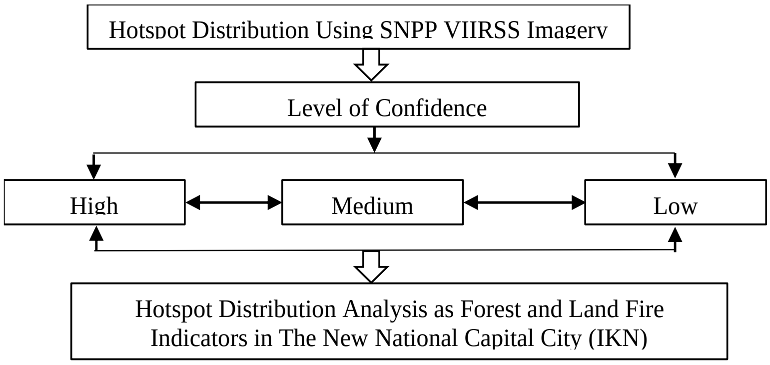


Figure 2. Research flow chart

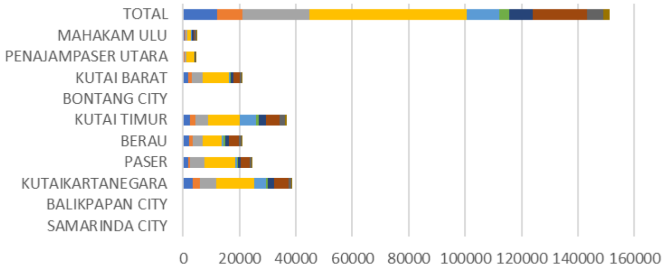
4. Result dan Discussion

Fires can be detected early through the number of hotspots available. The greater the number of hotspots, the higher and greater the potential for fire. The results of the study can be known the number of hotspots recorded from the S-NPP VIIRS Satellite Image from 2012-2021 at the National Capital Location (IKN) of the archipelago as many as 266.627 points. The number of hotspots in a year occurred in 2015 when there was an El-Nino phenomenon which caused the duration of the dry season to be longer than usual (8 until 10 months) with the number of hotspots reaching 56.539 points.

The hotspot data collection in this study is hotspot data from the results of recording VIIRS S-NPP satellite images for 2012-2022. Hotspots won't provide much information if they don't do advanced interpretation and analysis. Further analysis is needed to determine the potential emergence of hotspots in each region as an effort to mitigate land fires (Simanjuntak et al, 2020). Existing hotspots are processed and analyzed so that the distribution of hotspots in each area can be known. The results of hotspot processing at the location of the new national capital, namely in East Kalimantan Province, vary quite a bit at each Regency / City and District level from 2012-2022. The year 2022 was not found hotspots until May. The distribution of hotspots in 2012, 2013, 2014, 2015, and 2019 was highest in Kutai Kartanegara Regency. In 2016, 2017, 2018, 2020 and 2021 the highest in East Kutai Regency where in 2019 the highest Kutai Kartanegara Regency. The distribution of hotspots was highest in 2015 due to the influence of El-Nino which caused a long drought (Aisyah et al, 2021), where the highest distribution of hotspots in 2015 was also in Kutai Kartanegara Regency.

Hotspot data obtained from satellite imagery needs to be interpreted to be used as a determinant of land fire disaster prevention and mitigation policies (Harsoyo et al, 2022). Further analysis is also needed as an effort to prevent and mitigate land fire disasters by triggering potential fire points in vulnerable areas (Kumalawati et al, 2019).The highest distribution of hotspots in the 2012-2022 range is in Kutai Kartanegara Regency followed by East Kutai, Paser, Berau, and West Kutai Regencies. The country has a hotspot count above twenty thousand. As the core zone of IKN development, Kutai Kartanegara Regency has the highest distribution and number of hotspots among other districts, so it needs serious attention.

Details of hotspot distribution variations in 2012-2022 where in 2012, 2013, 2014, 2015, and 2019 Kutai Kartanegara Regency has the highest number of hotspot distribution compared to other districts. While in 2016, 2017, 2018, 2020 and 2021 the highest distribution of hotspots was in East Kutai Regency. The year 2022 was not found hotspots until May. The highest number of hotspots was in 2015 due to the influence of El-Nino which caused a long drought (Harsoyo et al, 2022), where the highest distribution of hotspots in 2015 was also in Kutai Kartanegara Regency.



	SAMARINDA CITY	BALIKPAPAN CITY	KUTAIKARTANEGARA	PASER	BERAU	KUTAI TIMUR	BONTANG CITY	KUTAI BARAT	PENAJAMPASER UTARA	MAHAKAM ULU	TOTAL
2012	0	0	3373	1661	2123	2374	0	1887	306	493	12217
2013	0	0	2488	838	1409	1997	0	1345	165	470	8712
2014	0	0	5827	5114	3514	4378	0	3830	611	548	23822
2015	0	0	13562	10964	6606	11446	0	9162	2881	1111	55732
2016	0	0	4013	554	723	5572	0	391	142	323	11718
2017	0	0	846	359	627	953	0	336	36	226	3383
2018	0	0	2030	967	1345	2542	0	962	78	449	8373
2019	0	0	5106	3115	3567	4795	0	2219	118	518	19438
2020	0	0	979	688	861	2185	0	484	39	419	5655
2021	0	0	470	319	415	673	0	212	8	185	2282
2022	0	0	0	0	0	0	0	0	0	0	0

Figure 3. Number of hotspots distribution from viirs s-npp image recording in 2012-2022 in the location of the new national capital

The distribution and number of hotspots are indicators of potential land fires (Kumalawati et al, 2021). Therefore, districts that have a high distribution and number of hotspots need preventive efforts in the form of appropriate and fast mitigation to minimize negative impacts and minimize the number of victims and property. Information on the distribution of hotspots in each region is crucial to be acquired and is known as an effort to mitigate and prevent forest and land fires.

The overall distribution of hotspots from 2012-2022 both in each Regency / City and the highest sub-district level is in Kutai Kartanegara Regency followed by East Kutai, Paser, Berau, and West Kutai Regencies (see Figure 3 and Table 2). The district has a high number of hotspots that are above twenty thousand. Kutai Kartanegara Regency is one of the districts that has the highest distribution and number of hotspots where the patent is the core location of IKN development so it needs serious attention. Districts with a high distribution and number of hotspots, the area is predicted to have a high potential for fire incidence (Adam, 2020; Harsoyo et al, 2022). Districts with high fire potential need appropriate and fast mitigation to minimize the negative impact of fires and minimize casualties as well as property. Seeing this, it is very necessary to note the distribution of hotspots in each region because it can be used as an indicator of the occurrence of forest and land fires. As we know, the more the number of hotspots with high accuracy, the higher the attention to fire.

Table 2. Number of Hotspot Distribution from VIIRS S-NPP Image Recording Year 2012-2022 in Each District in the Location of the New National Capital

No.	Regency/City	District	Hotspot
1	Samarinda City	Loajanan Hilir	11
		Palaran	378
		Samarinda Ilir	2
		Samarinda Ulu	24
		Samarinda Utara	185
		Samarindakota	5
		Sambutan	114

No.	Regency/City	District	Hotspot
		Sungaikunjang	39
		Sungaipinang	13
2	Balikpapan City	Balikpapan Barat	120
		Balikpapan Kota	2
		Balikpapan Selatan	10
		Balikpapan Tengah	257
		Balikpapan Timur	126
		Balikpapan Utara	84
3	Kutai Kartanegara Regency	Anggana	2,274
		Kembangjanggut	2,720
		Konahan	4,218
		Kotabangun	1,494
		Loajanan	1,540
		Loakulu	1,174
		Marangkayu	2,665
		Muarabadak	1,251
		Muarajawa	819
		Muarakaman	7,713
		Muaramuntai	2,695
		Muarawis	3,738
		Samboja	3,251
		Sanga- Sanga	228
		Sebulu	539
		Tabang	1,783
		Tenggarong	228
		Tenggarong Seberang	364
4	Paser Regency	Batuengau	5,372
		Batusopang	3,988
		Kuaro	1,106
		Longikis	1,947
		Longkali	3,532
		Muarakomam	1,318
		Muarasamu	3,104
		Pasirbalengkong	2,275
		Tanahgrogot	826
		Tanjungharapan	1,111
5	Berau Regency	Batu Putih	553
		Biatan	1,423
		Biduk-Biduk	148
		Gunungtabur	1,664
		Kelay	1,397
		Pulauderawan	3,308
		Sambaliung	3,854
		Segah	4,319
		Tabalar	1,189
		Talisayan	1,990
		Tanjungredeb	14

No.	Regency/City	District	Hotspot
		Telukbayur	1,331
6	Kutai Timur Regency	Batuampar	1,384
		Bengalon	9,027
		Busang	1,014
		Kaliorang	271
		Karangan	886
		Kaubun	2,033
		Kombeng	2,703
		Longmesangat	684
		Muaraancalong	5,280
		Muarabengkal	4,316
		Muarawahau	922
		Rantaupulung	1,382
		Sandaran	665
		Sangatta Selatan	1,161
		Sangatta Utara	1,190
		Sangkulirang	935
		Telen	1,613
		Telukpandan	1,449
7	Bontang City	Bontang Barat	29
		Bontang Selatan	1,780
		Bontang Utara	116
8	Kutai Barat Regency	Barongtongkok	372
		Bentian Besar	1,132
		Bongan	1,842
		Damai	3,070
		Jempang	1,965
		Linggangbigung	399
		Longiram	370
		Melak	387
		Mookmanaarbulatn	1,725
		Muaralawa	770
		Muarapahu	4,568
		Nyuatan	1,129
		Penyinggahan	610
		Sekolaqdarat	16
		Siluqngurai	1,838
		Tering	635
9	Penajam Paser Utara Regency	Babulu	466
		Penajam	1,658
		Sepaku	840
		Waru	1,420
10	Mahakan Ulu Regency	Laham	485
		Longapari	647
		Longbagun	1,476
		Longhubung	1,210
		Longpahangai	924
	Total		**154,627**

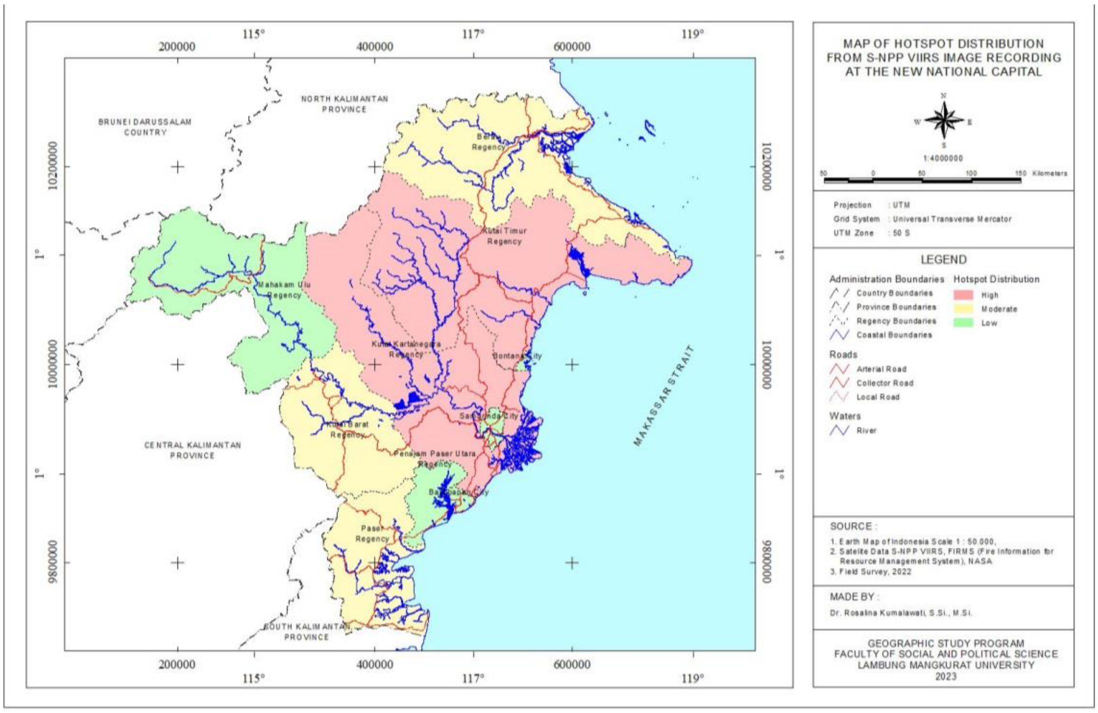


Figure 4. Map of hotspot distribution from s-npp viirs image

Spatial analysis is the analysis needed to describe the distribution of areas affected by hotspots in the new national capital. Therefore, the distribution of hotspots is carried out by categorizing the levels described in the equation formula (1) to (4). So that we can write down low level has values from 599 hotspots until 12.698 hotspots, medium level has values from 12.699 hotspots until 13.297 hotspots and high level has more that 13.297 hotspots. Figure 4 shows that Kutai kartanegara Regency and East Kutai Regency have the highest incidence of forest and land fire compared to other regions. According to Rosalina et al, 2019, forest and land fires can experience extensive area expansion due to wind as a medium for spreading forest fires, so that is why Kutai kartanegara and East Kutai Regencies have a high number of hotspots distribution due to the expansion of fire areas. The distribution of hotspots at the medium level occurs at the intersection of high-level areas, namely in the north and south (figure 4). This indicates a decrease in the incidence of fires in West Kutai, Berau and Paser regencies, which are areas with a moderate number of hotspots. Unlike the case with urban areas, it shows a low level for the distribution of hotspots, namely in the cities of Balikpapan, Samarinda City and Bontang City. However, North Penajam Paser and Mahakam Ulu regencies, which are not urban areas, have a low level of hotspot distribution.

Table 3. Total distribution of hotspots in the new national capital

Region	Total Of Hotspots	Level
Balikpapan City	599	Low
Samarinda City	771	Low
Bontang City	1,925	Low
Penajampaser Utara	4,384	Low
Mahakam Ulu	4,742	Low
Kutai Barat	20,828	Medium
Berau	21,190	Medium
Paser	24,579	Medium

Region	Total Of Hotspots	Level
Kutai Timur	36,915	High
Kutai Kartanegara	38,694	High

5. Conclusion

The highest distribution of hotspots from the results of recording S-NPP VIIRS satellite images at the location of the New State Capital is in Kutai Kartanegara Regency which is the core location of IKN. The distribution of hotspots can be an indicator of forest and land fires at the IKN location, so Kutai Kartanegara Regency needs intensive attention. The distribution of hotspots needs to be known because it can be a form of early detection and fire mitigation so that the negative impact of fires can be minimized.

Acknowledgments

This research is a National Competitive Basic Research which is an Indonesian-Dutch Cooperation using research grants with contract number 026/E5/PG.02.00.PL/2023.

References

A. A. Fitriany, P. J. Flatau, K. Khoirunurrofik, And N. F. Riama.. 2021. Assessment On The Use Of Meteorological And Social Media Information For Forest Fires Detection And Prediction In Riau, Indonesia.

Aflahah, E., Hidayati, R., Hidayat, R., and Alfahmi, F. 2019. Pendugaan Hotspot Sebagai Indikator Kebakaran Hutan Di Kalimantan Berdasarkan Faktor Iklim. Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal Of Natural Resources And Environmental Management), 9(2), 405-418.

Agustiar, A. B., Mustajib, M., Amin, F., and Hidayatullah, A. F. 2020. Kebakaran Hutan Dan Lahan Perspektif Etika Lingkungan. Profetika: Jurnal Studi Islam, 20(2), 124-132.

Ardiansah, A., Kadaryanto, B., and Oktapani, S. 2020. Penyuluhan Larangan Pembakaran Hutan Di Kampung Pinang Sebatang Berdasarkan Undang-Undang Kehutanan. Madaniya, 1(2), 71-79.

Almegi, A., Akmal, A., Alfiah, A., Nelvawita, N., and Novita, Y. 2022. Sebaran Spasial Titik Panas (Hotspot) Berdasarkan Penutupan Lahan Di Kabupaten Pesisir Selatan. El-Jughrafiyah, 2(1), 16-21.

Aldi Dhafri, A. 2021. Penerapan Koordinasi Penanggulanan Kebakaran Hutan Dan Lahan Pada Dinas Lingkungan Hidup and Kehutanan Dengan Badan Penanggulangan Bencana Daerah Provinsi Riau (Doctoral Dissertation, Universitas Islam Negeri Sultan Syarif Kasim Riau

A. J. Wulan And S. Subagio., 2016. "Efek Asap Kebakaran Hutan Terhadap Gambaran Histologis Saluran Pernapasan," Medical Journal Of Lampung University, Vol. 5, Pp. 162–167.

Adam, S. S. 2020. Evaluasi Area Kebakaran Lahan Dan Hutan Berbasis Hotspot Citra Modis. Scientico: Computer Science And Informatics Journal, 3(1), 19-34.

Andy.I, Judin.P And Wisnu Sunarmodo. 2019. Accuracy Level Analysis Of Hotspot From S-Npp Viirs And Terra/Aqua Modis Compare To Fire Event. Jurnal Penginderaan Jauh Dan Pengolahan Data Citra Satelit Vol 16 (1)

Arisman, A. 2020. Analisis Tren Kebakaran Hutan Dan Lahan Di Indonesia Periode Tahun 2015-2019. Jurnal Sains Teknologi Dan Lingkungan, 6(1), 1-9.

Aisyah, S., Wahyuningsih, S., and Amijaya, F. 2021. Peramalan Jumlah Titik Panas Provinsi Kalimantan Timur Menggunakan Metode Radial Basis Function Neural Network. Jambura Journal Of Probability And Statistics, 2(2), 64-74.

Bowen, M.R., Bompard, J.M., Anderson, I.P., Guizol, P., Gouyon, A. 2001. Anthropogenic Fires In Indonesia: A View From Sumatra. Dalam Peter, E., Radojevic, M. (Eds.), Forest Fires And Regional Haze In Southeast Asia. Nova Science Publishers, Huntington, New York, Pp. 41–66

Dicelebica, T. F., Akbar, A. A., and Rahayu, D. J. 2022. Identifikasi Dan Pencegahan Daerah Rawan Bencana Kebakaran Hutan Dan Lahan Gambut Berbasis Sistem Informasi Geografis Di Kalimantan Barat. Jurnal Ilmu Lingkungan, 20(1), 115-126

Edi, A. S., and Kurnianingtyas, A. P. 2020. Pemetaan Kebakaran Hutan Dan Lahan Kabupaten Tanah Bumbu Kalimantan Selatan Menggunakan Aplikasi Sistem Informasi Geografis. Jurnal Planologi, 17(2), 232-248.

Fitria, M. D. 2023. Sebaran Daerah Kebakaran Hutan Di Taman Nasional Way Kambas Menggunakan Pemodelan Normalized Burn Ratio Tahun 2021.

Giglio, Luis and Decroitre, J. 2003. Peningkatan Algoritma Deteksi Kebakaran Kontekstual Untuk Modis. Jurnal Penginderaan Jauh Lingkungan, 87, 273-282.

Goma, E. I., Lampang, D., Purwadi, F., Inayah, I., Sagala, L., Riska, R., and Deviani, D. 2022. Analisis Kebakaran Hutan Dan Lahan Di Samarinda (Analysis Of Forest And Land Fire In Samarinda). Jurnal Sains Informasi Geografi (J Sig), 4(2), 99-104.

Harsoyo, B., and Athoillah, I. 2022. Paradigma Baru Pemanfaatan Teknologi Modifikasi Cuaca Dalam Upaya Penanganan Bencana Kebakaran Hutan Dan Lahan Di Indonesia. Jurnal Sains and Teknologi Modifikasi Cuaca, 23(1), 1-9.

Ikhwan, M. 2016. Pemetaan Daerah Rawan Kebakaran Hutan Dan Lahan Di Kabupaten Rokan Hilir. Wahana Forestra: Jurnal Kehutanan, 11(1), 57-66.

Imansyah, F. F. 2021. Sistem Informasi Geografis Lahan Pertanian Rawan Kebakaran Di Kota Singkawang. Justin (Jurnal Sistem Dan Teknologi Informasi), 9(2), 289-299.

Indradjad, A., Purwanto, J., and Sunarmodo, W. 2019. Analisis Tingkat Akurasi Titik Hotspot Dari S-Npp Viirs Dan Terra/Aqua Modis Terhadap Kejadian Kebakaran. Jurnal Penginderaan Jauh Dan Pengolahan Data Citra Digital, 16(1), 53-60.

Johar, A., Vatresia, A., and Donny, I. A. 2023. Implementasi Metode Spatio Temporal Clustering Dengan Algoritma St-Dbscan Pada Titik Api Kebakaran Hutan Indonesia (2015-2020). Rekursif: Jurnal Informatika, 11(1), 1-9.

Karo, I. M. K. 2020. Implementasi Metode Xgboost Dan Feature Important Untuk Klasifikasi Pada Kebakaran Hutan Dan Lahan. Journal Of Software Engineering, Information And Communication Technology (Seict), 1(1), 10-16.

Kumalawati, R., Nasruddin, N., Yuni Kartika, N., and Agustarina, A. 2018. Pemetaan Sebaran Titik Panas (Hotspot) Untuk Indikasi Kebakaran Hutan Dan Lahan Di Kabupaten Tapin Provinsi Kalimantan Selatan.Prosiding Pertemuan Ilmiah Tahunan (Pit) Xx Iakatan Geograf Indonesia (Igi), Isbn. 978-623-93268-0-7. Penerbit Jurusan Pendidikan Geografi Fakultas Ilmu Sosial Universitas Negeri Manado.

Kumalawati, R., Nasruddin, N., Hendra Murliawan, K., Yuliarti, A., and Pangaribuan, A. N. 2020. Sebaran Hotspot Dan Komunikasi Masyarakat Dalam Menyikapi Bencana Kebakaran Lahan Gambut. Prosiding Seminar Nasional Geomatika 2020, Informasi Geospasial Untuk Inovasi Percepatan Pembangunan Berkelanjutan, Issn. 2614-7211.

Kumalawati, R., Yuliarti, A., Ali, S. D., Murliawan, K. H., Rijanta, R., Susanti, A., and Saputra, E. 2023. Hotspot Spatial Patterns Using Snnp-Viirs For Fire Potential Monitoring. International Journal Of Forestry Research, 2023.

Kumalawati, R., Yuliarti, A., Anggraeni, R. N., and Murliawan, K. H. 2021. Sebaran Hotspot Tahun 2012-2021 Di Kalimantan Selatan. Jurnal Geografika (Geografi Lingkungan Lahan Basah), 2(1), 1-10.

Kumalawati, R., Nasruddin, N., and Elisabeth, E. 2019. Strategi Penanganan Hotspot Unbtuk Mencegah Kebakaran Di Kabupaten Barito Kuala, Kalimantan Selatan. In Prosiding Seminar Nasional Lingkungan Lahan Basah (Vol. 4, No. 2, Pp. 351-356)

L. Tacconi., 2016. "Preventing ores And Haze In Southeast Asia,"Nature Climate Change, Vol. 6, No. 7, Pp. 640–643.

Maranatha, E. I., and Kusmayadi, I. M. 2020. Konstruksi Pemberitaan Kebakaran Hutan Dan Lahan Pada Tribun Jambi. Jurnal Kajian Jurnalisme, 3(2), 153-166.

Marlina, S., Lautt, B. S., Usup, A., and Sunaryati, R. 2020. Dampak Kebakaran Lahan Dan Hutan Terhadap Kesehatan Perempuan Di Kabupaten Pulang Pisau. Enviroscienteae, 16(3), 423-431.

Muhammad.A, Lili.S, And Riki.R. 2022. Pemetaan Tingkat Keparahan Kebakaran Hutan Dan Lahan Menggunakan Algoritma Normalized Burn Ratio (Nbr) Pada Citra Landsat 8 Di Kabupaten Muaro Jambi. Jurnal Geosains Dan Remote Sensing Vol 3 (1)

Nata, M. 2020. Kebijakan Pemanfaatan Teknologi Penginderaan Jauh Dalam Upaya Mendukung Penanganan Karhutla (Studi Kasus: Kalimantan Barat). In Prosiding Seminar Nasional Kebijakan Penerbangan Dan Antariksa V (Sinas Kpa-V) 2020 (Pp. 77-93). Pusat Kajian Kebijakan Penerbangan Dan Antariksa.

Nisa, A. N. M. 2020. Penegakan Hukum Terhadap Permasalahan Lingkungan Hidup Untuk Mewujudkan Pembangunan Berkelanjutan (Studi Kasus Kebakaran Hutan Di Indonesia). Jurnal Bina Mulia Hukum, 4(2), 294-312.

Purbahapsari, A. F., and Batoarung, I. B. 2022. Geospatial Artificial Intelligence For Early Detection Of Forest And Land Fires. Kne Social Sciences, 312-327

R. Ajin, A.-M. Loghin, P. Vinod, And M. Jacob., 2016. "Forest ore, Risk Zone Mapping, Using Rs And Gis Techniques: A Study In Achankovil Forest Division, Kerala, India," Journal Of Earth, Environment And Health Sciences, Vol. 2, No. 3, Pp. 109–115.

Rosalina, K., Dianita, A., and Elisabeth, E. 2019. Penyebab Kebakaran Hutan Dan Lahan Gambut Di Kabupaten Barito Kuala Provinsi Kalimantan Selatan. In Prosiding Seminar Nasional Ilmu Sosial, Lingkungan Dan Tata Ruang (Semnas Islt) Manajemen Bencana Di Era Revolusi Industri 5.0.

Rosalina, K., Nasruddin, N., and Rizki Nurita, A. 2021. Pemetaan Sebaran Hotspot Data Modis Aqua Dan Terra Di Kalimantan Selatan. In Prosiding Seminar Nasional Lingkungan Lahan Basah (Vol. 6, No. 2).

R. P. Nugraha, A. Fauzi, And M. Ekayani. 2019. "Ekonomi Pertanian, Sumberdaya, Dan Lingkungan: Analisis Pendapatan Usaha Pertanian Dan Peternakan," Jurnal Ekonomi Pertanian, Sumberdaya Dan Lingkungan, Vol. 2, Pp. 1–14.

Rozi, F., Akbar, A. A., and Kadaria, U. 2020. Hubungan Sebaran Titik Panas (Hotspot) Terhadap Kesehatan Masyarakat Kota Pontianak. Jurnal Teknik-Sipil, 20(2).

Saharjo, B. H., and Nasution, M. R. A. 2021. Pola Sebaran Titik Panas (Hotspot) Sebagai Indikator Terjadinya Kebakaran Hutan Dan Lahan Di Kabupaten Aceh Barat. Journal Of Tropical Silviculture, 12(2), 60-66.

Sastry, N. 2002. Forest Fires, Air Pollution, And Mortality In Southeast Asia. Demography, 39 (1): 1—23.

Saputro, J. G. J., Handayani, I. G. A. K. R., and Najicha, F. U. 2021. Analisis Upaya Penegakan Hukum Dan Pengawasan Mengenai Kebakaran Hutan Di Kalimantan Barat. Jurnal Manajemen Bencana (Jmb), 7(1).

Sari, N. A., and Putra, R. A. 2020. Analisis Statistik Deskriptif Titik Panas Di Wilayah Sumatera Selatan. In Prosiding Seminar Nasional Sains Dan Teknologi Terapan (Vol. 3, Pp. 51-57).

Simanjuntak, M. S., Kusnandar, D., and Debataraja, N. N. 2020. Pemetaan Rawan Kebakaran Hutan Di Kalimantan Barat Tahun 2020. Bimaster: Buletin Ilmiah Matematika, Statistika Dan Terapannya, 11(5).

Syarifah, H., Poli, D. T., Ali, M., Rahmat, H. K., and Widana, I. D. K. K. 2020. Kapabilitas Badan Penanggulangan Bencana Daerah Kota Balikpapan Dalam Penanggulangan Bencana Kebakaran Hutan Dan Lahan. Nusantara: Jurnal Ilmu Pengetahuan Sosial, 7(2), 398-407.

Stole, F., Chomitz, K.M., Lambin, E.F., Dan Tomich, T.P. 2003. Land Use And Vegetation Fires In Jambi Province, Sumatera, Indonesia. Forest Ecology And Management 179 (2003): 277— 292.

Trestiyan, P. A., and Roziqin, A. 2022. Pemetaan Sebaran Titik Panas (Hotspot) Tahun 2017-2021 Di Kota Batam. Jurnal Teknologi Dan Riset Terapan (Jatra), 4(2), 64-68.

Utami, W., Ndaru, A. Y., Widyastuti, A., and Swardiana, I. M. A. 2017. Pengurangan Resiko Kebakaran Hutan Dan Lahan Melalui Pemetaan Hgu Dan Pengendalian Pertanahan (Studi Kasus Provinsi Riau). Bhumi: Jurnal Agraria Dan Pertanahan, 3(2), 232-245.

Uddin, M. A., Qadri, U., and Zulianto, D. 2021. Upaya Badan Penanggulangan Bencana Daerah Dalam Penanggulangan Dan Pencegahan Kebakaran Hutan Dan Lahan Di Kota Pontianak. Mimbar: Jurnal Penelitian Sosial Dan Politik, 10(2), 112-121.

Wibowo, K. A. 2019. Manajemen Penanganan Kebakaran Hutan Dan Lahan (Karhutla) Guna Peningkatan Ekonomi Kerakyatan. Jurnal Studi Sosial Dan Politik, 3(1), 69-83.

Wibowo, A. D., and Munir, R. M. 2021. Eksplorasi Kebijakan Penanganan Bencana Kebakaran: Studi Kasus Di Indonesia. In Prosiding Seminar Nasional Lingkungan Lahan Basah (Vol. 6, No. 1).

Wibowo, B., and Dediansyah, A. 2020. Sejarah Lingkungan Sebagai Pendidikan Pengurangan Resiko Bencana Di Kabupaten Ketapang Kalimantan Barat. Khazanah Pendidikan, 14(1).

Yusuf, A., Hapsoh, H., Siregar, S. H., and Nurrochmat, D. R. 2019. Analisis Kebakaran Hutan Dan Lahan Di Provinsi Riau. Dinamika Lingkungan Indonesia, 6(2), 67-84.