Journal of Natural Resources and Environmental Management
12(4): 749–756. http://dx.doi.org/10.29244/jpsl.12.4.749–756
E-ISSN: 2460-5824
http://journal.ipb.ac.id/index.php/jpsl

Ground water level as an indicator of forest and land fires in Tanjung Jabung Timur Regency, Jambi Province

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Article Info:
Received: 18 - 08 - 2022
Accepted: 17 - 09 - 2022

Keywords:
Fire, groundwater level, peatland

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Abstract. *Land and forest fires in Indonesia are one of the environmental issues that become the discussion of the public every year at the local, national, and international levels. Several factors influencing peatland fires' incidence are groundwater levels and climatic factors, especially rainfall. The Peatland and Mangrove Restoration Agency have established a Peatland Water Monitoring System) based on sensored equipment in the field to measure water level, but the data utilization has not been optimal yet. This study aims to (1) analyze the relationship between water level and hotspots as an indicator of fires and (2) analyze the relationship between water level and rainfall. Statistical analyses were done using SPSS, and hotspot mapping was supported by Arc Map GIS 10.5. Tanjung Jabung Timur Regency has a hotspot distribution for January 2019 – December 2021 of about 916 hotspots. The correlation test of hotspots with water level obtained a moderate correlation value of –0,408 and a P-Value of 0,001, which shows that hotpots with groundwater level have a negative relationship, which means that the high value of the the water level will be followed by a decrease in the hotspot. As for the correlation of water level with rainfall, it gets a high correlation value of 0,705 with a P-Value value of 0,001 and has a positive notation, which means that the high amount of rainfall will be followed by the high water level. It seems that groundwater level has a good possibility as land and forest fires indicator in peatland area.*

How to cite (CSE Style 8th Edition):
Putri AI, Syaufina L, Puspaningsih N. 2022. Ground water level as an indicator of forest and land fires in Tanjung Jabung Timur Regency, Jambi Province. JPSL **12**(4): 749–756. http://dx.doi.org/10.29244/jpsl.12.4.749–756.

INTRODUCTION

Land and forest fires become one of the environmental issues discussed by the public at the local, national, and international levels every year. The occurrence of forest and land fires can have various impacts, such as economic, social, and ecological aspects. Data from the Ministry of Environment and Forestry in 2017-2021 indicates a decreasing trend of fire occurrence, though a great fire in 2019 burned about 1.649.258 ha. Previous research has explained that forest and land fires occur both on peat or mineral land (Syaufina 2008), but Material (2007) in Yusuf *et al.* (2019) explained that, in general, fires often occur on peatlands. It is because when the fire is ignited, it will quickly spread through the biomass above the peat layer, or below the peat land surface. Peatland is a wetland ecosystem that naturally has an essential function as a life support ecosystem, a hydrological regulator of the amount of water discharger during the rainy and dry seasons, and controlling climate change (Saharjo *et al.* 2018).

The most crucial threat to peatlands in Indonesia is forest and land fires often referred to as peatland fires. The fires are closely related to land use change, including forests conversion to other land use such as oil palm plantations and other uses. Febrianti (2018) explains that the land use change on peatlands usually begins with land clearing and then continues with drying the land by drainage channel construction, which is susceptible to fire.

Peatland fires are also often indicated by hotspots. Areas detected by satellites as hotspots are the areas that have relatively higher temperatures compared to the surrounding area. The satellites that are often used to detect hotspots as indicators of forest and land fires are the NOAA and Terra/Aqua satellites. The clustered hotspots found in 2 – 5 days indicate the occurrence of forest and land fires in an area (LAPAN 2015). The occurrence of peat fires, which are indicated by hotspots, has a close relationship with rainfall as a contributing factor to the occurrence of fires (Syaufina and Hafni 2018). The most crucial factor influencing peatland fires is moisture content, which has critical moisture content ranging from 110% to 117.39% (Syaufina 2008).

In peatland areas, the moisture content is influenced by Ground Water Level (GWL). Over the last few years, the Peatland and Mangrove Restoration Agency (BRGM) has developed Peatland Ground Water Monitoring System (SIPALAGA) by deploying automatic equipment in the field. In 2020, 142 GWL monitoring types were installed in 7 fire-prone provinces in Sumatra and Kalimantan. However, the data utilization from the system seems to be not optimum yet. Therefore, it is necessary to study the GWL data obtained from the sensors of SIPALAGA to determine the risk of peatland fires. The aims of this study were (1) to analyze the relationship between Ground Water Level (GWL) and hotspots as the indicator of forest and land fires occurrences and (2) to analyze the relationship between the GWL and rainfall.

METHOD

Research Location and Period

The research was conducted from March – August 2022 The selected research location is peatland which is administratively located in Tanjung Jabung Timur Regency, Jambi Province. The spatial data analysts are carried out at the Remote Sensing and GIS Laboratory, Forest Management, Faculty of Forestry and Environment, IPB University.

Data Collection Methods

The softwares used in this study were Microsoft Excel 2019, SPSS, and Arc Map GIS 10.5 (Table 1). The flow chart of data processing and analyses is shown in Figure 1. The data analysis applied in this study includes descriptive and statistical analysis. Daily groundwater level data for the period January 2019 – December 2021 was obtained from the Peatland and Mangrove Restoration Agency (BRGM). Hotspot data from January 2019 – December 2021 using ≥ the 80% confidence level was derived from the Lapan Modis Catalog, and the daily rainfall data for the period January 2019 – December 2021 was downloaded from the official website of Meteorology, Climatology, and Geophysical Agency (BMKG) (http://bmkg.go.id). The data were then descriptively classified using Microsoft Excel 2019. Statistical analysis was applied using the SPSS software to test the correlation between groundwater level, hotspots, and the GWL with rainfall. Arc Map GIS 10.5 was used to map the hotspots on the study area.

Table 1 Source research data

Data Type	Source
Daily peatland groundwater level (GWL) data	Peatland and Mangrove Restoration Agency (BRGM)
Daily Rainfall data	Meteorology, Climatology, and Geophysical Agency (BMKG) (http://bmkg.go.id)

Daily Hotspots data	National Institute of Aeronautics and Space (LAPAN) (http://modis-catalog.lapan.go.id)
Map of peatland distribution on Sumatra Island	Indonesia Center for Agricultural Land Resource Research and Development (BBSDLP)

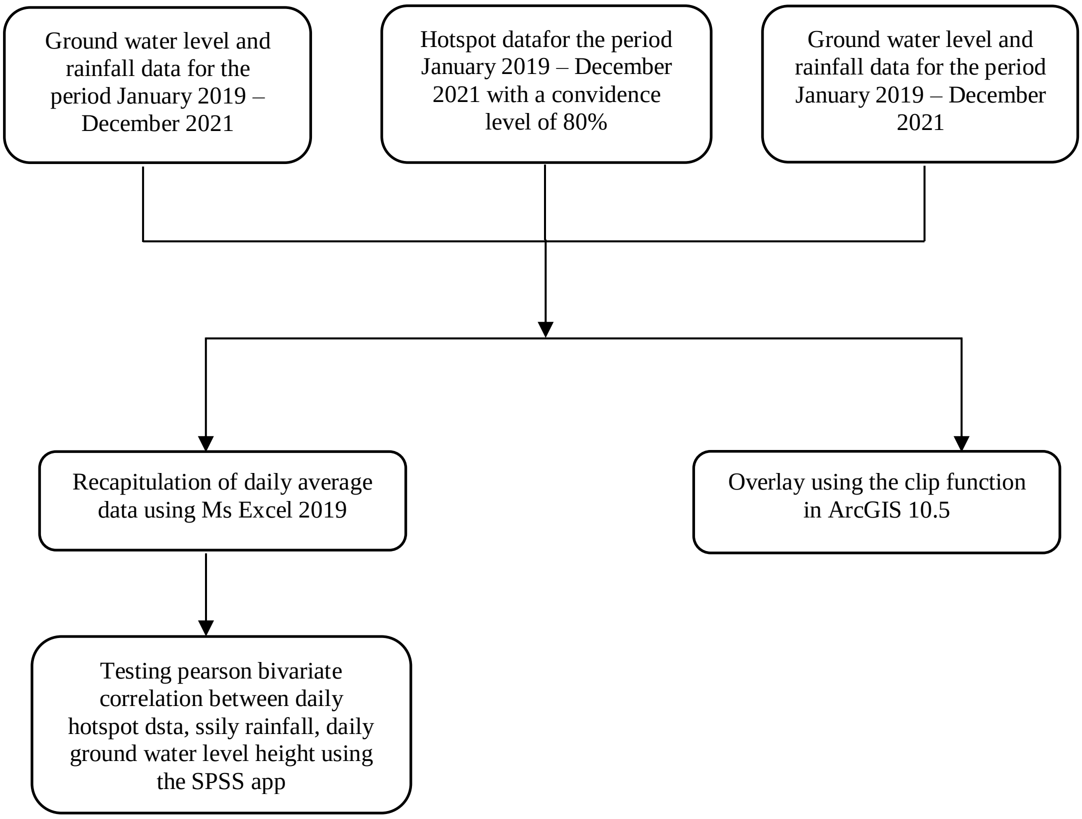

Figure 1 Flow chart of data analysis of groundwater level, hotspot, and rainfall

RESULTS AND DISCUSSION

General Conditions of the Study Area

Tanjung Jabung Timur Regency, Jambi Province, geographically located between 0°53' - 141' S and between 103°23' - 104°31' E. Tanjung Jabung Regency is bordered by the South China Sea in the northeastern, on the south is bordered by Muaro Jambi Regency and South Sumatra Province. To the east, it is bordered by the South China Sea, while on the west, it is bordered by Tanjung Jabung Barat Regency and Muaro Jambi Regency. The administrative area of Tanjung Jabung Timur Regency has 11 sub-districts, 20 urban villages, and 73 villages. Tanjung Jabung Timur Regency has a wet tropical climate with an average annual rainfall ranging from 2.000 - 3.000 millimeters per year, of which 8 - 10 months are wet and 2 - 4 months are dry. The average rainfall of the wet month is 179 - 279 mm, and the dry month is 68 - 106 mm. Tanjung Jabung Timur Regency has an area of 544.500 ha. In comparison, of the total area there are around 41,33% (225.047,60 ha) is a Production Forest, Protected Forest, and Tahura areas, as well as the Berbak National Park area of 138.242 ha. In addition, Agricultural and Non-Agricultural Cultivation Areas cover 319.452,40 ha (58,67%) (BPS Tanjung Jabung Timur 2021).

Hotspot Distribution in 2019 - 2021

Hotspot information is a pixel with a temperature value above a certain threshold from remote sensing results. According to the ministerial regulation of Environment and Forestry No. P.8/ME NLHK/SETJEN/KUM.1/3/2018 on the fixed procedure of field ground checking of hotspot information and or forest and land fires, which explain that the hotspot data can be a strong indicator for forest and land fires occurrences with specific characteristics, including clustering hotspots, occur in three consecutive days, and smoke indication in satellite image. Figure 2 shows that most hotspots appear in a cluster in peatlands areas as a strong indicator for forest and land fire occurrences. It is strengthened by Syaufina and Sitanggang (2018), the occurrence of hotspots consecutively for at least three days in adjacent locations can be a strong indicator of forest and land fires. The number of hotspot distributions from 2019-2021 has a total of 916 hotspots (Figure 3.). The highest incidence of fires occurred in 2019, then decreased in 2020, and slightly increased in 2021. The decline in the number of hotspots in 2020 seems to be due to an outbreak of a disease called "COVID-19". According to Syaufina *et al.* (2021), the emergence of the coronavirus (COVID-19) pandemic in early 2020 has triggered significant consequences throughout the global community, including Indonesia, which influenced the occurrence of forest and land fires. It is due to large-scale regulations on social restrictions that were put in place that may prevent burning activities as the main causes of forest and land fires in Indonesia.

According to the central government regulation in Law Number 6 of 2018, it is explained that in areas suspected of being infected with a disease and the possibility of spreading disease or contamination, it is necessary to carry out an activity often known as PSBB (large-scale social restrictions). Therefore, implementing large-scale PSBB activities ultimately allows people to stay at home and reduce crowds. However, Figure 4 explains that in 2021 the hotspots are back to increasing. This trend is because COVID-19 cases in Indonesia are declining, allowing people to leave their homes and carry out activities just like before the COVID-19 pandemic.

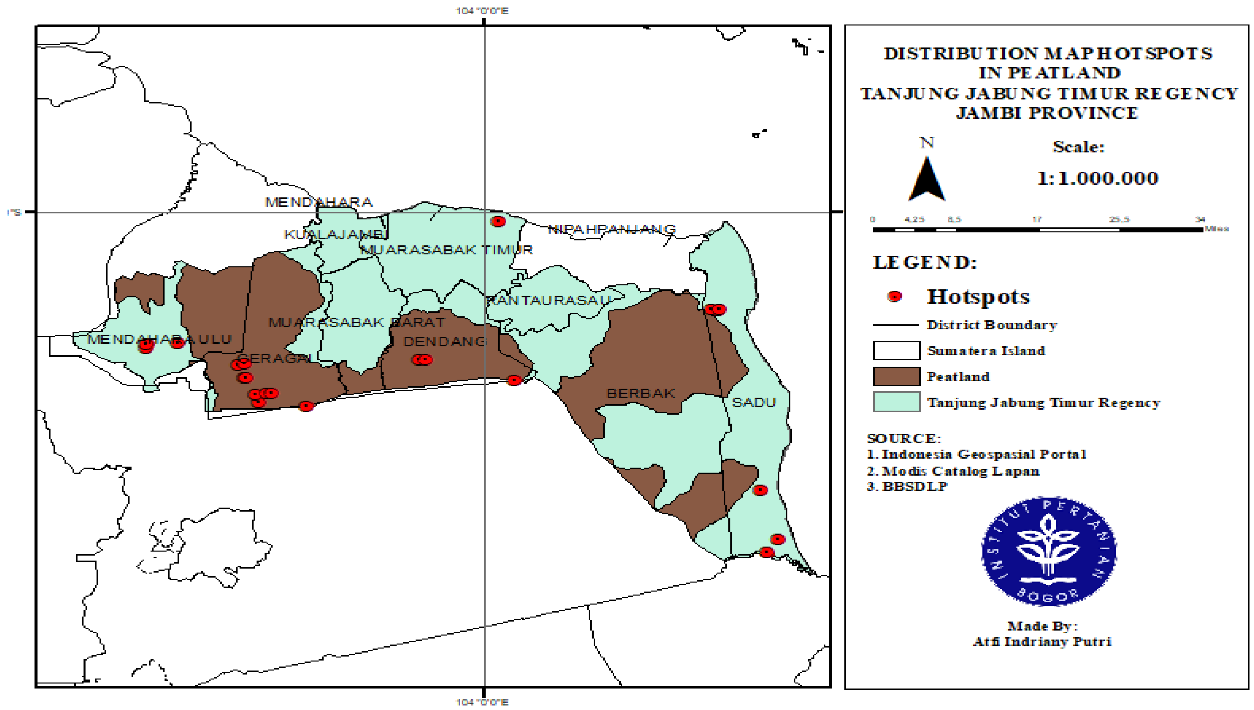

Figure 2 Peatland distribution map with hotspots of Tanjung Jabung Timur Regency, Jambi Province, for January 2019 – December 2021

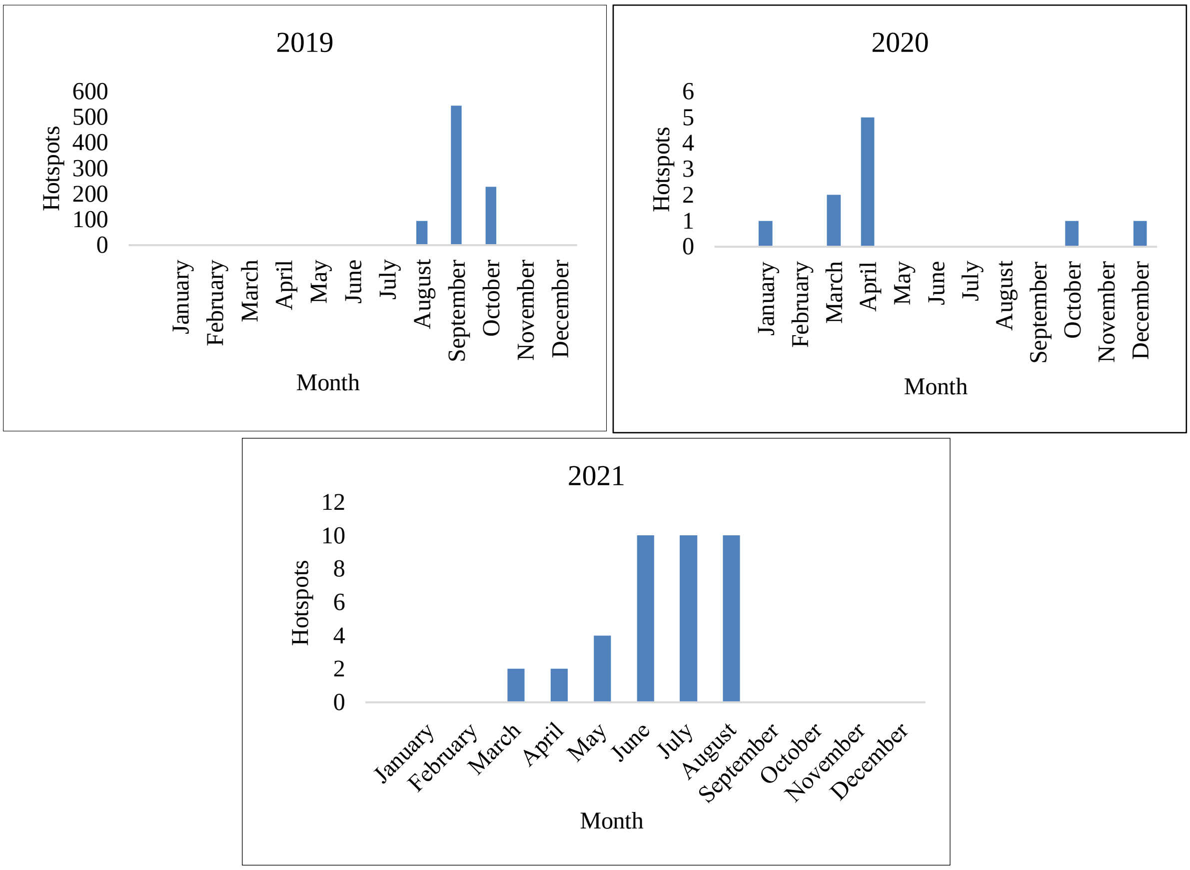

Figure 3 Distribution of hotspots 2019 - 2021 in Tanjung Jabung Timur Regency, Jambi Province

Correlation Between Ground Water Level (GWL) and Rainfall

The impact of peatland fires in 2015 was an increase in the area of degraded peat swamp forests (Putra *et al.* 2018). According to Taufik *et al.* (2015), when peatlands are degraded due to land clearing or the construction of drainage canals, water in peatlands easily flows out, eventually making the peatlands dry. Based on the research of Putra *et al.* (2008) in Kalimantan, peat fires occurred in mid-August when daily rainfall reached its minimum value, and the peat water level decreased. The water level in this study was measured by leveling the data every 10 minutes, then recapitulated to get daily data on water levels in one day. Then to see the strength of the relationship, it is necessary to test the correlation between the GWL and daily rainfall data.

Figure 4 shows that the daily rainfall value ranges from 0 – 21,55 mm, followed by the daily water level value ranges from –0,16 - (–0,92) m. As for the value of the highest rainfall of 21,55 mm is followed by a water level of 0,054 m. According to Wakhid *et al.* (2019), peatlands' water level generally follows rainfall variations. In other words, the canal's water level is strongly influenced by rainfall. The Pearson bivariate relationship test showed that the relationship between daily water level and daily rainfall was positively correlated with (+) 0,705, and this correlation was classified as a strong relationship class. In addition, the positive value of this relationship means that there is an increase in the amount of daily rainfall with an increase in daily water level or vice versa. This increase in rainfall will be followed by the increase in water level.

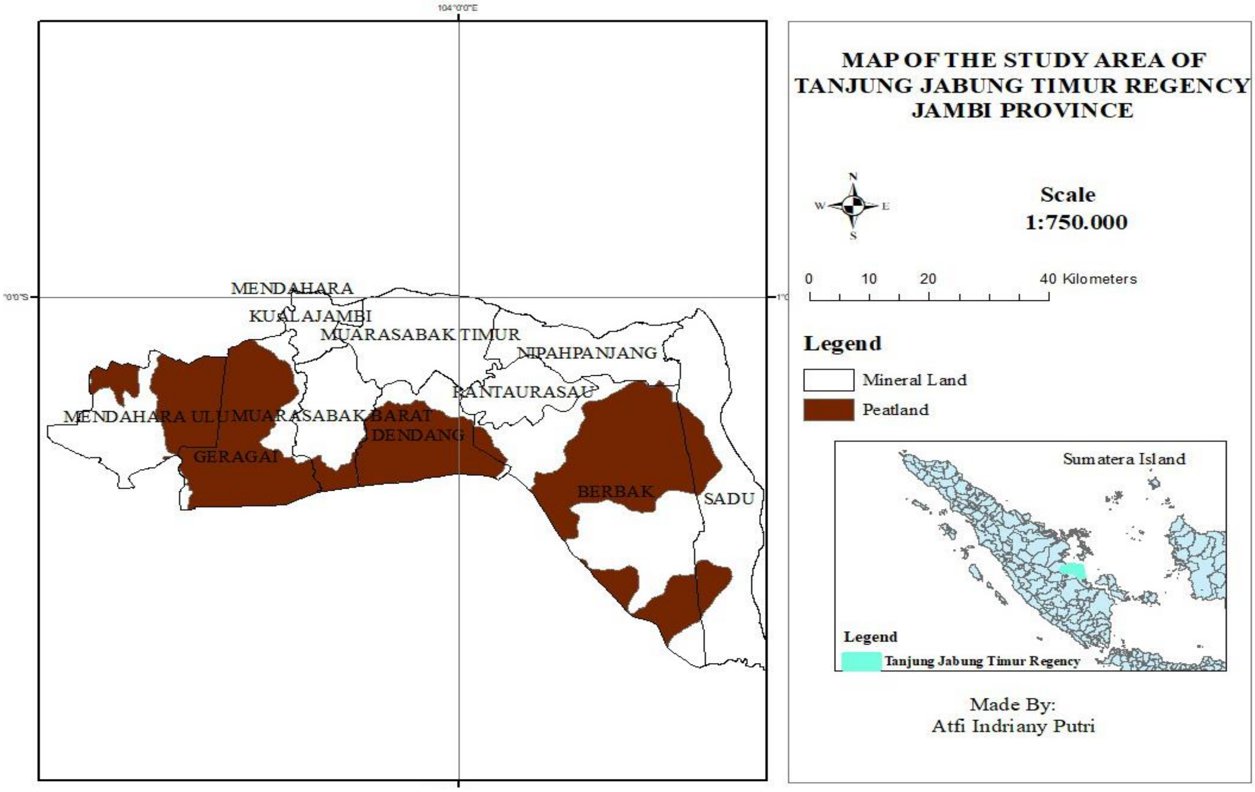

Figure 4 Map of the study area of Tanjung Jabung Timur Regency, Jambi Province

Correlation between Ground Water Level and Hotspots

In addition to being influenced by climatic factors, peatland fires can also be predicted by hotspots and groundwater levels as fire indicators. Rahman *et al.* (2017) explained that a fire incident on peatland could be assessed using groundwater level data. Figure 5 illustrates that the average monthly hotspot ranges from 1 – 545, while the monthly water level ranges from 0,12 - 0,8 m. In addition, the highest daily hotspots is 81 found when the water level decreases to 0,87 m.

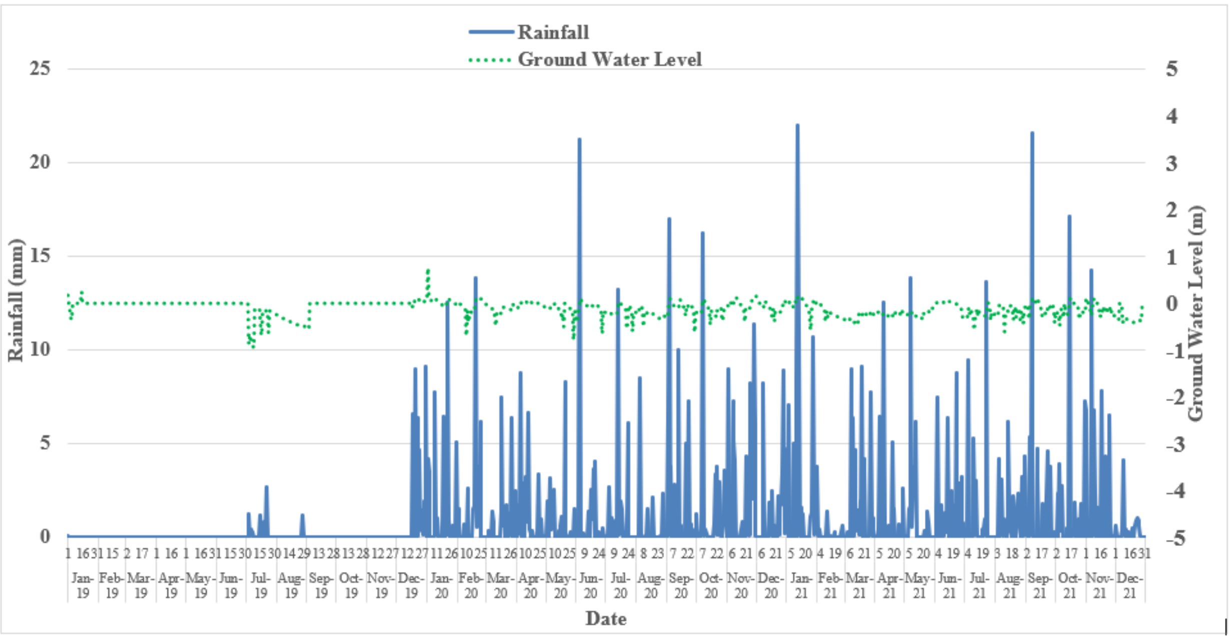

Figure 5 Distribution of daily ground water level and rainfall in Tanjung Jabung Timur Regency, Jambi Province, for the period January 2019 – December 2021

Figure 6, which illustrates that the highest groundwater level shows a small number of fires which can be seen in January every year. Pearson's bivariate correlation test showed that the relationship between the groundwater level and hotspots was (-) 0,408, which means that it is included in the category of moderate correlation. This correlation test shows a negative sign, meaning that an increase in groundwater level groundwater level coincides with a decrease in the number of hotspots, or a decrease in the number of hotspots will be indicated by an increase in the groundwater level. It is very much in line with research conducted by Prasetia and Syaufina (2020), which explains that the inverse relationship of a correlation can identify that an increase in groundwater level will follow a decrease in hotspots. Since there is a positive correlation between rainfall and groundwater level, then the occurrence of fires will be followed the rainfall negatively as well.

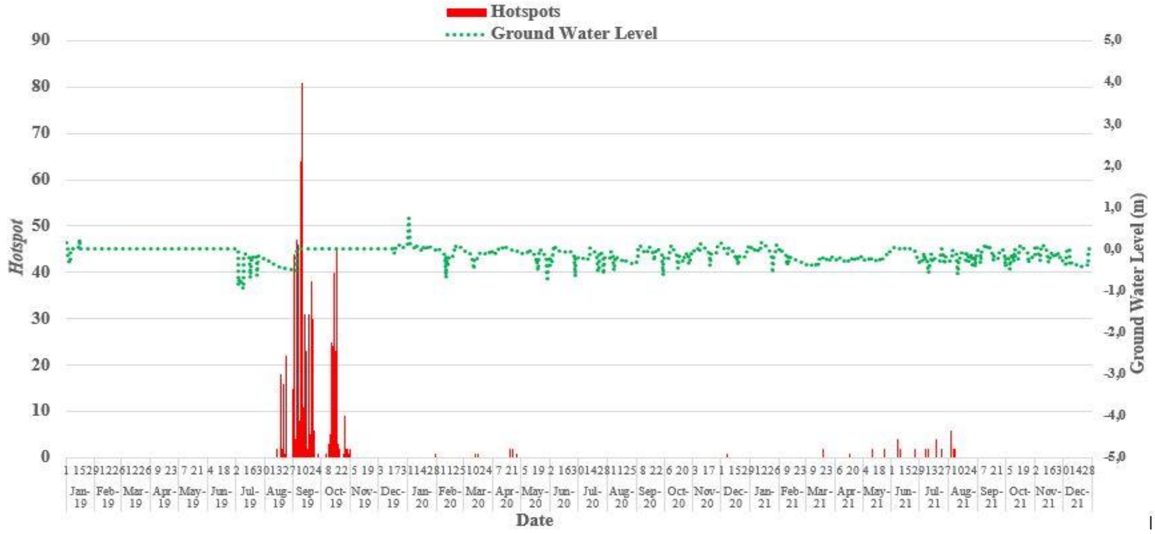

Figure 6 Distribution of daily hotspot and ground water level 2019 - 2021 in Tanjung Jabung Timur Regency, Jambi Province, for the period January 2019 – December 2021

CONCLUSION

From January 2019 – December 2021, about 916 hotspots were found in Tanjung Jabung Timur Regency, Jambi Province, which the highest being in 2019 (868 hotspots). As an indicator of forest and land fires, hotspots have a robust negative correlation with groundwater level and rainfall. The decrease in groundwater level has an impact on an increase in hotspots. The rainfall influences the groundwater level, which is indicated by a strong positive correlation. The highest daily hotspot is 81, which is found at a groundwater level of –0,87 m and rainfall of 0 mm.

ACKNOWLEDGMENT

The authors would like to thank the Peatland and Mangrove Restoration Agency for providing data on Ground Water Levels in Tanjung Jabung Timur Regency, Jambi Province, to Net-Peat: Networked ASEAN Peatland Communities for Transboundary Haze Alert Project-Indonesia part for publication support.

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