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Identification of Spatial Autocorrelation on Forest and Land Fire Areas in Kalimantan Tengah Province

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Abstract: *Spatial autocorrelation is an analytical method for measuring the similarity between attributes in a space. The occurrence of spatial randomness indicates the presence of spatial patterns such as clustered, scattered or random. One of the method of measure spatial autocorrelation is Moran's I method or Moran's Index. Moran's Index is commonly used to see events such as forest fire disasters. The forest fires that occurred in Kalimantan Tengah had a very damaging impact. Apart from destroying the environment, forest fires also causing health problems and affecting the community's economy, especially for those who depend on forest products. The purpose of this study is to visualize and determine the shape of the distribution of cases of forest and land fires in Kalimantan Tengah Province using Moran's I statistical measurements. The data and methods used are maps and data on the area of forest and land fires in regency/manicipality in Kalimantan Tengah Province in 2018-2022 obtained from the Ministry of Environment and Forestry of the Republic of Indonesia. The results of this study shows that the distribution of forest fires from 2018 to 2022 are known to have no significant changes, while between regions tend to have similarities with their neighbors. And it is concluded that forest and land fires occur randomly or not in groups and there is no spatial autocorrelation.*

Keywords: Kalimantan Tengah; Forest and land fires; Moran's I; Spatial Autocorrelation

1. INTRODUCTION

Spatial autocorrelation is an analytical method for measuring the similarity between attributes in a space. The occurrence of spatial randomness indicates the presence of spatial patterns such as clustered, scattered or random. A positive spatial autocorrelation indicates that adjacent locations have similar values and tend to cluster together. Negative spatial autocorrelation indicates that adjacent locations have different values and tend to spread. Meanwhile, no spatial autocorrelation is on indication of random local patterns [1]. One of the method to measure spatial autocorrelation is using the Moran's I method or Index's Moran..

Moran's I is a global spatial autocorrelation measure used to analyze the spatial relationship of an event. This analysis describes the spatial autocorrelation in the region as a whole [2]. In its application it is commonly used to obserce events such as forest fire disasters.

Indonesia as a trophical country is known for its rainforest that hold extraordinary biodiversity. But unfortunately, Indonesia's forests also often experience forest fires which damage the environment and threaten human life.

Forest fires are a phenomenon that often occurs in Indonesia which is of local and global concern [3]. Forest fires are not new, in Kalimantan forest fires have occurred since the 17th century [4]. However, it was only in 1980 that there was an increase in the area and intensity of forest fires, especially in Sumatra and Kalimantan.

Kalimantan Tengah is one of the provinces in Indonesia which has abundant forest wealth. Unfortunately, Kalimantan Tengah also frequently experiences forest fires which damage the environment and threaten human life. Forest fires in Kalimantan Tengah are often caused by human factors, such as land clearing by burning forests illegally. In addition, climate change can also affect the frequency and intensity of forest fires in this area.

The forest fires that occurred in Kalimantan Tengah had a very damaging impact. Apart from damaging the environment, forest fires can also cause serious health problems for humans, especially for those who suffer from respiratory problems. In addition, forest fires can also affect the community's economy, especially for those who depend on forest products. This article discusses the determination and visualization of the distribution of widespread cases of forest fires in Kalimantan Tengah Province using Moran's I statistical measurements.

2. LITERATUR REVIEW

2.1 Forest and Land Fires

Forest and land fires are forest and/or land burning events, both naturally and by human actions, resulting in environmental damage that causes ecological, economic, socio-cultural and political losses [5].

Types of forest and land fires:

a. Canopy fires, are fires in the crowns of trees, generally developing from surface fires which are controlled too late,

there is an influence of wind on the spread of fire, the most difficult to extinguish.

b. Surface fires, which are above ground level, where there is an influence of wind on the spread of fire, are the easiest to control.

c. Bottom fires, occur on organic fuel (garbage, humus, peat layers) which are below the surface of the soil, there is almost no wind effect on the spread of fire, there is little smoke making it difficult to detect and extinguish.

2.2 Spatial Autocorellation

Spatial autocorrelation is the correlation between a variable and itself based on space it can also interpreted as a measure of the similarity of objects in a space (distance, time, and area). If there is a systematic pattern in the distribution of a variable then there is spatial autocorrelation. Spatial autocorrelation shows that attribute values in certain areas are related to values in other areas that are closely located or neighboring [6].

2.3 Moran's I

Moran's I coefficient is the development of Pearson's correlation on univariate series data which is used to test spatial dependencies or autocorrelation between observations or locations. The hypothesis used is [7]:
H_0: I=0 (there is no autocorrelation between locations)
H_1: I≠0 (there is autocorrelation between locations)
With a value of Moran's I:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Information:
x_i = location variable data i (i=1,2,…,n)
x_j = location variable data j (i=1,2,…,n)
$\bar{x}$ = mean
w_{ij} = weight matrix
n = number of observations (location)

Moran's I index values range between -1 and 1. If $I > I_0$, the data has a positive autocorrelation. If $I < I_0$, the data has a negative autocorrelation.

$$E(I) = I_0 = -\frac{1}{n-1}$$

2.4 Moran's Scatterplot

The pattern of clustering and distribution between locations can be presented with Moran's Scatterplot (Figure 1), which shows the relationship between the observed values at a location (standardized) and the average observed values from neighboring locations to the location in question [7]. The scatterplot consists of four quadrants, namely:

a. Quadrant I (High-High), shows locations that have high observation values surrounded by locations that have high observation values.
b. Quadrant II (Low-High), shows locations that have low observation values surrounded by locations that have high observation values.
c. Quadrant III (Low-Low), shows locations that have low observation values surrounded by locations that have low observation values.
d. Quadrant IV (High-Low), shows locations that have high observation values surrounded by locations that have low observation values.

Quadrant II (LH)	Quadrant I (HH)
Quadrant III (LL)	Quadrant IV (HL)

Fig 1: Moran scatterplot

3. METHODS

This study uses secondary data in the form of maps and data on the area of forest and land fires in regrency/municipality in Kalimantan Tengah Province from 2018-2022 obtained from the Ministry of Environment and Forestry of the Republic of Indonesia (https://sipongi.menlhk.go.id/).

Data were analyzed using the autocorrelation spatial analysis method, namely Moran's I and depicated using Moran Plot.

4. RESULT AND DISCUSSION

4.1 Descriptive Data

Kalimantan Tengah Province consists of 13 regencies and 1 municipality. Based on data from BPS – Statistics of Indonesia regarding the area of forest areas and marine conservation areas in Indonesia, in 2022 the total area of the forest cloud cover for Kalimantan Tengah province covers 12.6 million hectares, which is the third largest forest area compared to other provinces in Indonesia after Papua, Kalimantan Timur, and Kalimantan Utara.[8].

4.2 Distribution of Land and Forest Fires in Kalimantan Tengah

Forest fires are one of the natural disasters that often occur in Indonesia. The following is the distribution of forest fires that occurred in each regency/municipality in Kalimantan Tengah Province from 2018 to 2022. In a spatial analysis to determine the existence of spatial autocorrelation, the main component needed is a location map. The map is used to determine the proximity relationship between regency/minicipality in Kalimantan Tengah. This will make it easier to weight each location or area.

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Fig 2: Map of Forest and Land Fires Distribution in 2018

In 2018, the 3 highest distibution of forest and land fire are in Kotawaringin Timur, Kapuas, and Pulang Pisau. Meanwhile, the regency with the smallest area of forest and land fires are Lamandau, Gunung Mas, and Murung Raya.

Fig 3: Map of Forest and Land Fires Distribution in 2019

In Figure 3 it is found that Barito Utara has the smallest area of forest and land fires. Meanwhile, Barito Selatan turned seeing an increase in forest and land fires area.

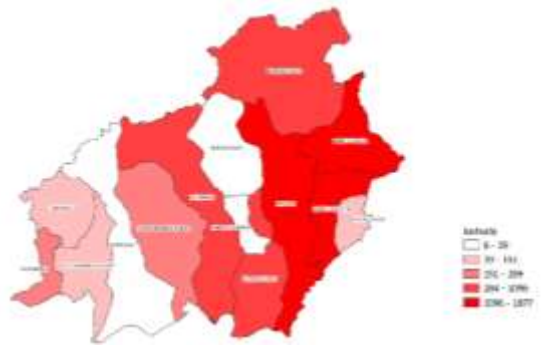

Fig 4: Map of Forest and Land Fires Distribution in 2020

In 2020, the region with the smallest area of forest and land fires changed, to Seruyan, Gunung Mas and Palangka Raya. Meanwhile, Kapuas remains as the area with the highest fire distribution.

Fig 5: Map of Forest and Land Fires Distribution in 2021

Based on Figure 5, Murung Raya, which was previously has the smallest fire area, become the largest in 2021. Meanwhile, other areas have not experienced major changes.

Fig 6: Map of Forest and Land Fires Distribution in 2022

In 2022, the region with the smallest fire areas will change to the districts of Pulang Pisau, Barito Timur and Palangka Raya. Other areas have not experienced major changes.

From the map of Kalimantan Tengah province it is known that there are 14 regencies/minicipality so that the spatial weighting matrix will be 14x14 in size. Every year the change in the area of forest fires in Kalimantan Tengah does not change significantly, judging from the color, which does not differ too much. For example, in 2018 the most northen regency Murung Raya, was white, meaning it had the smallest area of forest fire until 2019 it was still white. In 2020 to 2022 the total area of forest fires has increased slightly but there is no significant difference. This is the same case as the other region in Kalimantan Tengah.

4.3 Autocorrelation

Calculed ucing Moran's I, the spatial autocorrelation value can be seen in table 1.

Table 1: Moran's Index Value

Years	Moran's I	Pvalue
2022	-0.1268	0.6088
2021	-0.0627	0.4383
2020	-0.1743	0.6936
2019	-0.1237	0.6214
2018	-0.1403	0.7174

Based on the results in table 1, it is found that from 2018 to 2022 there is a negative autocorrelation, which means that the area of forest fires that occurred in Kalimantan Tengah Province occurred randomly. It can be said that the forest fine distribution not forming groups or patterns. The pvalue from Moran's I test from 2018 to 2022 is more than 0,05 so that the results is failed to reject H_0, which means there is no spatial autocorrelation. From these results it can be cancluded that there is a possibility that this model does not have spatial dependence.

4.4 Moran Plot

Moran plot indicating the relationship between observed values at a location is shown in the following figure.

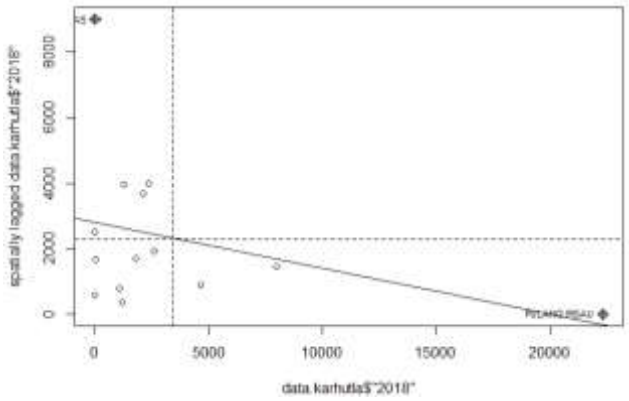

Fig 7: Moran Plot of the area of the forest and land fires in 2018

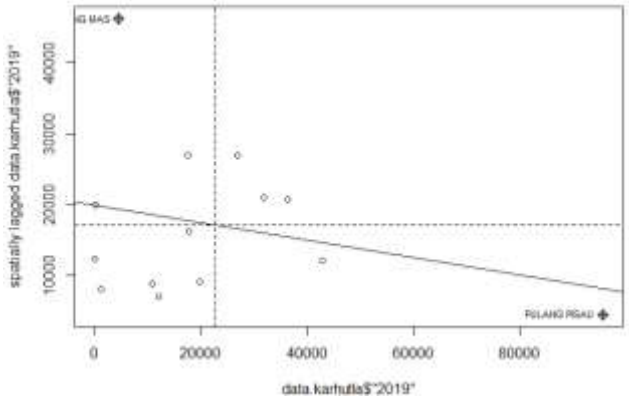

Fig 8: Moran Plot of the area of the forest and land fires in 2019

Based on Figures 7 and 8, the moran plot of the distribution of forest fires in 2018 is the same as in 2019, with Pulang Pisau Regency in Quadrant 4 in the HL category and Gunung Mas Regency in Quadrant 2 with the LH category.

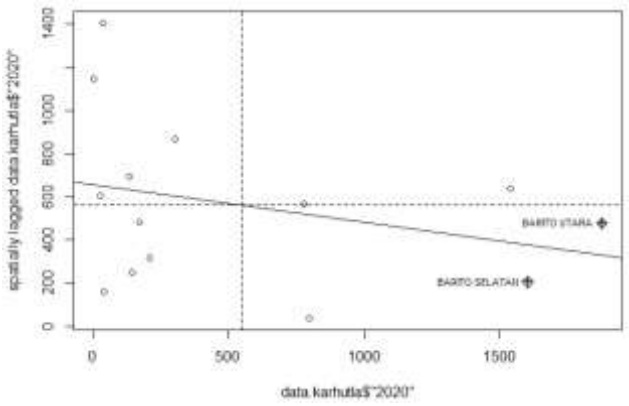

Fig 9: Moran Plot of the area of the forest and land fires in 2020

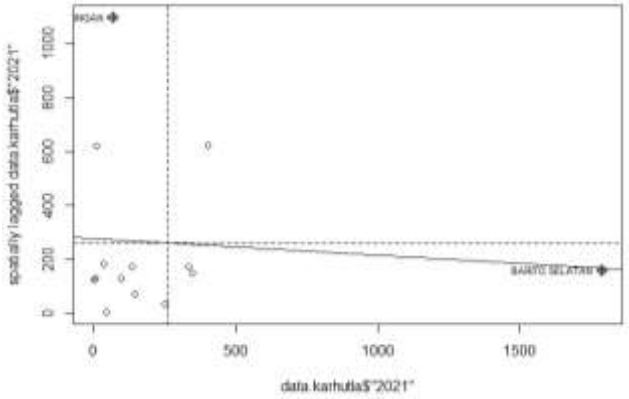

Fig 10: Moran Plot of the area of the forest and land fires in 2021

In 2020 it is known that there are two regencies, Barito Selatan and Barito Utara in quadrant 4 in the HL category, while in 2021, in Quadrant 4 there is only be Barito Selatan Regency, and Katingan Regency in quadrant 2.

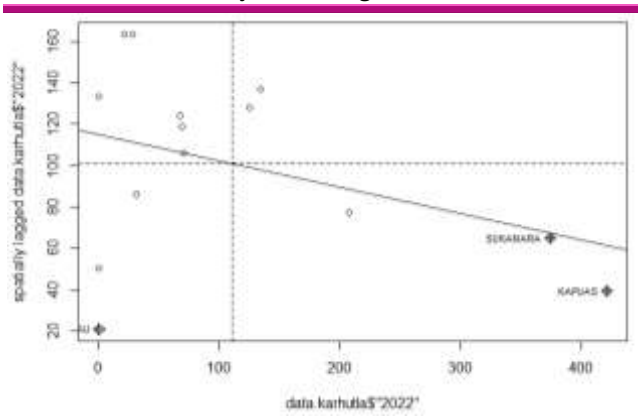

Fig 11: Moran Plot of the area of the forest and land fires in 2022

The Moran plot in 2022 has differences compared to previous years, in quadrant 4 there are Sukamara and Kapuas regency, while in quadrant 3 with the LL category there is Pulang Pisau regency.

5. Conclusion

The conclusion obtained based on data on the area of forest and land fires in regency/minicipality in Kalimantan Tengah Province in 2018-2022, it was found that forest and land fires occurred randomly or not in groups and there was no spatial autocorrelation.

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