Spatial Analysis of Fire Occurrence in Jakarta, Indonesia

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Abstract. The occurrence of fire incidents in urban villages of Jakarta Special Capital Region significantly impacted losses, necessitating prevention and handling efforts. Therefore, this study aims to analyze the spatial influence of social and physical variables (independent variables) such as sex ratio, vulnerable age population, number of buildings, and size of slum areas on fires (dependent variable) in Jakarta Special Capital Region. The analysis area includes five municipalities of the Jakarta Special Capital Region. Secondary data were obtained from the Central Agency of Statistics of Jakarta Special Capital Region, maps from the official site jakartasatu.jakarta.go.id, and publication data from the Government of Jakarta Special Capital Region for 2020. Furthermore, the quantitative approach in descriptive and inferential analysis, determined using Microsoft Excel and GeoDa version 1.20.0.10, was used to evaluate the spatial relationships between adjacent sub-districts. Although the regression data processing results using GeoDa were significant, the spatial regression results with Lagrange Multiplier (LM) Lag and Lagrange Multiplier (LM) error > 0.05 were insignificant and significant when using the parameter 0.1. This means fire symptoms in the Jakarta Special Capital Region do not have a spatial effect, contrary to the clustering observed between dependent and independent variables using Morans'I and Scatter Plots. The results of this study can aid the Jakarta provincial government in preventing and handling potential fires by restructuring slum areas to minimize the likelihood of such incidents.

1. Introduction

According to the National Disaster Management Agency, a disaster is an occurrence or sequence of events that jeopardize and interrupt the lives and means of support of people. These incidents are usually due to natural/non-natural factors, human actions leading to fatalities, ecological degradation, property damages, and psychological ramifications [1]. Fire poses a threat by emitting flames from the initial outbreak until smoke and gas are produced. It is common in residential and workplace settings in urban and rural areas. The causes of fires are very diverse, including 1) electrical installations (imperfect/ nonstandard installation), 2) Cooking utensils (gas/kerosene/electric stoves), and 3) Occupant behavior (indiscriminate smoking, overload of using electrical equipment) [2]. To construct building structures, it is preferable to ensure building feasibility by adhering to the parameters specified in the building permit called IMB. In structures with building permits, the buildings, and land must comply with building codes stated in government regulations, ministerial regulations, regional regulations, and government regulations. Building permits determine the building's clearance to its surroundings, building density, air circulation, and green open space, resulting in reduced fire risks.

Fires occur in various places, including the Jakarta Special Capital Region of Indonesia, where they pose a significant threat and must be prevented effectively. According to data from the Statistics Management Unit for the Department of Communication, Informatics and Statistic of Jakarta Special Capital Region in 2021, there were 1,505 cases of fires in Jakarta Special Capital Region, the majority of the cases were caused by electrical disturbances as many 938 cases, 180 cases of explosions or gas leaks, and 43 cases of candles and cigarette butts [3]. Residential buildings accounted for the highest number of fire incidents as much 461 cases, followed by outdoor installations as much 438 cases and trading stalls as much 14 cases [3]. In 2020, the Fire and Rescue Department in Jakarta Special Capital Region handled 5,043 fire cases [1], which is alarming given the status of Jakarta as a primate city and a role model for other Indonesian cities in terms of safety and management. Preventative measures and effective handling are necessary to curb the incidence of fires. Therefore, this study aims to investigate the potential spatial relationship between various parameters (independent variables) such as sex ratio, number of vulnerable age populations (aged < 5 years and > 65 years), number of buildings (of various types), and the area of slums in a sub-district, with the incidence of fires in all urban villages (sub-district) in Jakarta Special Capital Region (except the thousand islands) as the dependent variable.

This study aims to analyze the spatial correlation between social and physical variables and fire incidents in the Jakarta Special Capital Region. It covers the five municipalities of North Jakarta, South Jakarta, Central Jakarta, West Jakarta, and East Jakarta, without including the Thousand Islands regency, as these five municipalities are geographically contiguous without being separated by water. The findings can be utilized as a reference for policymakers to improve fire prevention and handling measures in the Jakarta Special Capital Region.

2. Methods

2.1 Literature Review

The occurrence of fires results from the triangular reaction of combustible materials, oxygen, and heat [4]. Unfortunately, fire disasters occur unexpectedly, and their time and location cannot be predicted, making an unwanted event [5]. According to the Ministerial Decree of Public Works Republic Indonesia No. 11/KPTS/2000, fires can be triggered by various factors, including cigarette butts, intentional actions, and electrical short circuits. The ignition of fires in organic matter is due to the presence of fuel, oxygen, and heat in specific [6]. Fires can cause significant losses, including 1) Humans (in the form of casualties), 2) Materials (value of buildings and assets damaged), 3) the Environment (flora and fauna, thermal effects as well as increased CO_2 gas and pollution), 4) Economic (financial losses), 5) Social (mass layoffs), etc [7]

Fires could happen in any location, including various types of buildings. Fires in residential areas have certain characteristics [2]. These include:

1) It generally occurs in solid materials such as wood, building materials, paper, and cloth.
2) It takes the form of an open fire with rapid propagation, as the distance between buildings is often close, causing burning material to increase the intensity of the fire.
3) Accessing fire suppression, such as fire fighting vehicles, is still difficult.
4) There is still limited availability of fire extinguishing media, especially adequate water sources.

Areas at risk of fire hazards are characterized by several factors, such as the physical condition of buildings, which are often found in densely populated areas with irregular patterns and low-quality building materials. Additionally, there is often a lack of firefighting facilities and narrow distances between houses, which make it difficult for firefighting vehicles to access the area. The lack of functioning *hydrants* also facilitates the spread of fire [8]. To address this issue, hazard area mapping can be used for urban planning analysis, disaster emergency response planning, insurance determination, and ecological learning. This type of mapping or zoning of hazard areas is a form of non-structural disaster mitigation, which can reduce the risk level of a disaster [4].

To determine the fire hazard level is identified two parameters, land use, and building density. The fire hazard level on land use can be classified into social, economic, physical, and ecological or environmental vulnerabilities based on the number of fire hazard risk classifications [2]. Fire hazard risk classification is divided into the following categories:

a. Social Vulnerability parameters consist of the:
   (1) Population Density Parameters
   (2) Vulnerable Group Parameters, which consist of Sex ratio, Poverty ratio, Ratio of People with Disabilities, Age Group Ratio
b. Economic Vulnerability indicators can be obtained from the following parameters:
   (1) Productive land calculated in rupiah
   (2) Gross Regional Domestic Product (GRDP)
c. Physical Susceptibility indicators are obtained from the following parameters:
   (1) Building Density
   (2) Availability of Emergency Facilities (critical)
   (3) Availability of Public Facilities
d. Ecological or environmental vulnerability

The theoretical basis of this study was based on the theory developed by Muzani in 2020 [2]. Despite several studies discussing fires, none has explored the potential of fires in a specific area by analyzing the spatial correlations between relevant variables using GeoDa software. Fires in an area are very likely to be influenced or affect other areas, expressed by Tobler in Anselin that 'Everything is related to everything else, but near things are more related to each other", everything is interconnected, but things that are closer affect more than things farther away [9]. Spatial regression is one of the statistical methods in determining the relationship between variables dependent and independent using consideration of location linkage [10]. The spatial dependencies could identify by spatial autocorrelation, basically spatial autocorrelation explain a certain systemic pattern in adjacent areas of observed values [11].

In geography, there is a concept known as spatial correlation, which refers to the techniques used by nearby locations to have a stronger influence on each other [12]. This idea has been adopted by other disciplines, such as biology and sociology [12], highlighting the importance of considering spatial relatedness when analyzing data. Estimating spatial influences can be conducted using various methods, such as spatial regression, which involves examining the relationship between a dependent variable and one or more independent variables while taking into account their spatial location. By using an equation model, the value of the dependent variable based on the known values of the independent variables can be predicted [13].

An analytical tool using spatial correlation is spatial econometrics, which is an intersection between spatial analysis and econometrics, introduced by Belgian economist Jean Paelinck in 1974, parameters used regression analysis [13]. The results of regression analysis in econometrics are expected to provide unbiased forecasting, so it cannot be separated from the classical assumptions proposed [14]. In spatial analysis can be seen an interdependence of locations to another (neighboring), to test the interdependence could use several methods such as spatial autocorrelation with Moran's I and LISA (Local Indicator Spatial Association) [15]. Spatial autocorrelation is a measure of the similarity of objects in spatial [16]. Specialized software programs such as GeoDa that offer functions for mapping and visualizing geospatial data in the form of points or polygons are used to facilitate spatial data analysis. These to Ordinary Least Squares (OLS) are useful for econometric study and other applications [9]. General model for spatial correlation describe in equation below [17]

$$Y = \beta_0 + \beta 1 * X_1 + \beta 2 * X_2 + \ldots\ldots \beta_n * X_n \quad (1)$$

Where

Y = dependent variable

β_0 = Constant

$X 1. X_2, \ldots X_n$ = Independent Variable

$\beta_1, \beta 2, \ldots \beta_n$ = Regression coefficient values for $X_1, X_2, \ldots X_n$

Spatial regression models are used to investigate the impact of linkages between regions, but spatial patterns are not able to explain the use of statistical analysis [18]. To test a the spatial effect of independent variables on dependent variable should do a spatial dependency test, namely the Lagrange Multiplier (LM) test. There are two possible types of spatial dependencies, namely: spatial error and spatial lag [13]. Considered spatial error when there is a linear relationship among errors or no homoscedasticity. Considered spatial lag when there is a linear relationship among errors and the dependence among observed values is added in an area with the same value with the nearest area [14]. The Spatial Error Model or Lagrange Multiplier (LM) Error and the Spatial Lag Model or Lagrange Multiplier (LM) Lag were used to examine the correlation between locations. The first step to determine the appropriate model is analyzing the Ordinary Least Squares (OLS) using classical regression. the Lagrange Multiplier (LM) probability of the OLS test should be checked before rejecting H_0. Furthermore, when both the Lagrange Multiplier (LM) Error and Lagrange Multiplier (LM) Lag do not reject H_0, the most powerful model with the highest score is determined [13]. H_0 means there is no global or no local spatial autocorrelation [19].

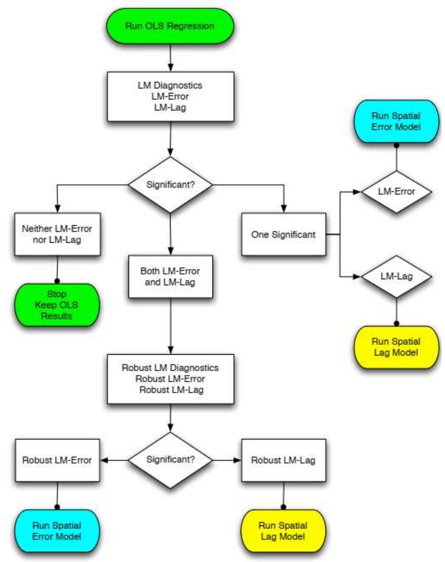

Figure 1. Spatial regression decision-making process
source: Anselin, 2005

For spatial dependence testing, can use the Moran's Test method. Moran's I is generated after classical regression model test. An element that plays an important role in spatial modeling is spatial weighting to describe Spatial proximity (neighbouring). Neighbouring is described by contiguity bases where an area intersects with each other regions, based on geographical distance (distance) described by the distance between polygon center points (area) [13]. There are several alternative ways of defining the binary matrix that reflect the closeness of relationships between regions such as Linear contiguity, Rook contiguity, Bishop contiguity, Double linear contiguity, and Queen contiguity [13]. The most commonly used alternative is Queen Contiguity [17].

2.2 Previous Studies

There are several journals related to fires analysis shown in table below.

Table 1. Comparison of Previous Studies Related to Fires

NO	JOURNAL TITLE	DESCRIPTION
1	Fire Risk Level in Terms of Building Density and Material Type in Residential Houses in Sungai Dama Village, Samarinda City	Determining the main factors contributing to fire disasters in densely populated areas
2	Slum Arrangement Prone to Fire Disasters in Lingkas Ujung Village, Tarakan City	Identifying the characteristics of slums in Lingkas Ujung Village
3	Fire Hazard Vulnerability in the Urban Village Area: The Case of Balubur Tamansari Area in Bandung City	Identifying the vulnerability of the Balubur Tamansari area to fire hazards using spatial approaches and disaster risk analysis
4	Settlements in the densely populated Peneleh sub-district of Genteng District, Surabaya City	Identifying vulnerability of potential fire hazards, specifically those with irregular settlement patterns
5	The Effect of Building and Environmental Arrangement on Fire Disaster Risk in Nyamplungan Village, Surabaya City	Determining how building arrangement and environment affect the risk of fire disasters in the Nyamplungan village

Source: Data Precess, 2023

The journal of "Fire Risk Level in Terms of Building Density and Material Type in residential houses in Sungai Dama Village, Samarinda City" is imperative to determine the main factors contributing to fire disasters in densely populated areas. The study assessed the risk based on several factors, including building density, building materials, building age, roof use, wall type, electricity, road access, and availability of water sources in the Dama River Village area of Samarinda City. Data were collected through direct observation, interviews, and literature review with settlement blocks used as mapping units to assess settlement fire vulnerability, density, patterns, quality of settlement materials, and internal accessibility. The result showed that the field conditions in the observed locations were divided into three categories, and all three locations had a high vulnerability to fire [4].

The journal of "Slum Arrangement Prone to Fire Disasters in Lingkas Ujung Village, Tarakan City" discussed identifying the characteristics of slums in Lingkas Ujung Village. It assessed the vulnerability of settlement fires, along with developing building plans. The method involved descriptive-evaluative analysis based on field observations, evaluations, and questionnaires with a weighting system for the level of slums and fire hazards. The result found that Lingkas Ujung Village is a water village with mostly non-permanent and slum building structures. Areas categorized as slums have a higher tendency to be prone to fire, which is influenced by factors such as building density, building structure, accessibility, and water sources. The conclusions drawn from the study include 1) The higher the building density, the worse the environmental conditions, and the tighter the building distances, the greater the risk of fire. 2) Ease of access contributes significantly to the vulnerability of slums to fire hazards, where narrow and small connecting roads make it difficult to handle fires. 3) The typology of slums in the form of semi-permanent and non-permanent structures increases the risk of fire. 4) Limited water supply and poor infrastructure in slums make it difficult to handle fires, as water is a crucial resource in fire management [20].

The journal of "Fire Hazard Vulnerability in the Urban Village Area: The Case of Balubur Tamansari Area in Bandung City" aimed to identify the vulnerability of the Balubur Tamansari area to fire hazards using spatial approaches and disaster risk analysis. Furthermore, descriptive analysis was used to identify areas with high fire vulnerability. The spatial parameters used in this study included population density, building quality, building density, and road network density, while disaster risk was evaluated based on hazard, vulnerability, and capacity parameters. The results found that the Balubur Tamansari area is at high risk of fire vulnerability due to several factors. These include a lack of community capacity in fire suppression, a densely populated area, low accessibility due to narrow alleys and roads that hinder the evacuation process during a fire, and low building quality due to the prevalence of irregular villages and non-permanent buildings [21].

The Journal of "Settlements in the densely populated Peneleh sub-district of Genteng District, Surabaya City", identifying vulnerability of potential fire hazards, specifically those with irregular settlement patterns. Areas vulnerable to fire hazards are densely populated settlements with irregular patterns, with the variables comprising residential building density, patterns, types of roofs and walls, electricity, accessibility, and water sources. Data were collected through observations on Google Earth sketches and surveys in the Jagalan area, divided into five settlement blocks with sample selection using the grid method. The study concluded that the high potential for fire is caused by factors such as the high density of residential buildings, building patterns, building age, and electricity, with supporting variables such as access roads, availability of water sources, and hydrants [5].

The journal of "The Effect of Building and Environmental Arrangement on Fire Disaster Risk in Nyamplungan Village, Surabaya City" aimed to determine how building arrangement and environment affect the risk of fire disasters in the Nyamplungan village. The identification process was carried out using the *Walkthrough Analysis Technique*, comprising three types of observations, namely single directional view, liner side view, and four directional views. Furthermore, primary and secondary data were collected through observation and literature survey, respectively. The indicators used are 1) physical indicators of buildings such as the characteristics of shelves between buildings, building height, function, type of material, and availability of open space. 2) Environmental indicators, including hierarchical characteristics of roads, water sources, and power grids; 3) Fire facility indicators comprising building exits, fire extinguishers, and evacuation routes, and 4) Fire suppression criteria indicators, including pattern setting function, pattern setting system, solid forming element, void forming element, linkage forming element in a strategic cultural manner, and collectively. The results study showed that the characteristics of buildings, environments, and fire facilities in the Nyamplungan village increased the risk of fire disasters. However, solid-forming buildings (terrain blocks), voids (open linear systems), and linkage (corridors and side definitions) were identified as characteristics to reduce fire disasters, and these should be optimized in efforts to decrease fire risk [22].

2.3 Research Methods

The study utilized a quantitative approach with both descriptive and inferential analysis techniques. Descriptive analysis involves the use of tabulation, cross-tabulation, and scatter plot to examine the relationships between independent and dependent variables. The inferential analysis involved conducting both classical Ordinary Least Squares (OLS) and spatial regression analyses to explore linkages between variables that are directly spatially related to adjacent neighborhoods. Microsoft Excel and GeoDa software version 1.20.0.10 were used to analyze the data. Unit analysis using 261 urban village (sub-district) in Jakarta Special Capital Region covers the five municipalities of North Jakarta, South Jakarta, Central Jakarta, West Jakarta, and East Jakarta.

The data collection method involved utilizing secondary data from multiple sources. The main data sources were from the Central Bureau Of Statistics of Jakarta Special Capital Region in 2020 and regional apparatus organizations (OPD) of Jakarta Government, such as the Capital Investment Office and One-Stop Integrated Services of Jakarta Special Capital Region (DPMPTSP), Public Housing and Settlement Area Office of Jakarta Special Capital Region (DPRKP), Jakarta Special Capital Region Provincial Deputy Administrator, and Fire and Rescue Service of Jakarta Special Capital Region (DPKP), all from 2020. The data was acquired from jakartasatu.jakarta.go.id website and further processed in Microsoft Excel.

All the data used were from the year 2020, as the latest data for 2021 and 2022 have not yet been fully released. The data primarily consists of the number of fire incidents based on urban villages in Jakarta Special Capital Region, which is the dependent variable (Y) obtained from the data jakarta.go.id website [23]. The independent variables (X), such as sex ratio and vulnerable population (aged < 5 years and > 65 years), were also collected from the same website. The number of buildings was obtained from data on the jakartasatu.jakarta.go.id website [23], while the data on the area of slums were obtained from the Public Housing and Settlement Area Office (DPRKP) and the Deputy Administrator of Jakarta Special Capital Region [24]–[27].

The initial hypotheses are as follows:

1) The greater the sex ratios (male to female) and the higher the numbers of vulnerable age populations of both male and female (aged < 5 years and > 65 years), the greater the risk of fire incidents, with a spatial relationship between adjacent urban villages.
2) The greater the number of buildings with various functions with an increase in the density of slums and population in urban villages, the possibility for the potential increase in the risk of fire incidents and spatial relationships with adjacent urban villages.

The study focused on classifying fire hazards based on two types of vulnerability, namely social and physical vulnerability. Social vulnerability (code KS) was assessed using a limited number of parameters considered representative, including sex ratio and age group ratio, which corresponded to the number of vulnerable age populations. Meanwhile, physical vulnerability (code KF) was represented by the density of buildings, which corresponded to the area of slum buildings, as well as the number of buildings in a given urban village.

Table 2. Operationalization of variables

VARIABLE	DESCRIPTION	DATA TYPE
# Fire	Number of fires occurance in one village during 2020	Interval
KS 1	Sex Ratio	Ratio
KS 2	Number of Vulnerable Age Population	Interval
KF 1	Slum Building Area	Interval
KF 2	Multiple Buildings	Interval

Source: Data Process, 2023

In this study, the dependent variable is the number or rate of fires, denoted by "Y." Several parameters, denoted by "X," serve as independent variables, including the number of female residents, buildings, vulnerable age residents (both male and female, aged < 5 years and > 65 years), and slums, which may increase the potential for fires. The number of buildings in a given urban village is related to building density. Therefore, a spatial relationship through spatial analysis using GeoDa software will be determined by examining the relationship between the dependent and independent variables. The results of the GeoDa analysis will be compared to the theoretical framework outlined above.

Table 3. Dependent and independent variables in 1 sub-district (urban village)

VARIABLE	VARIABLE TYPE	CODE
Number of Fires in 1 Sub-district	Y (dependent)	JML_KBKRN
Sex Ratio in 1 sub-district	X1 (independent)	RJK
Number of vulnerable age populations (<5 years old and > 65 years old) in 1 sub-district	X2 (independent)	JML_U-RTN
Slum Building Area in 1 sub-district	X3 (independent)	LS_BGN_KMH
Number of Buildings with various functions in 1 sub-district	X4 (independent)	JML_BGN

Source: Data Process, 2023

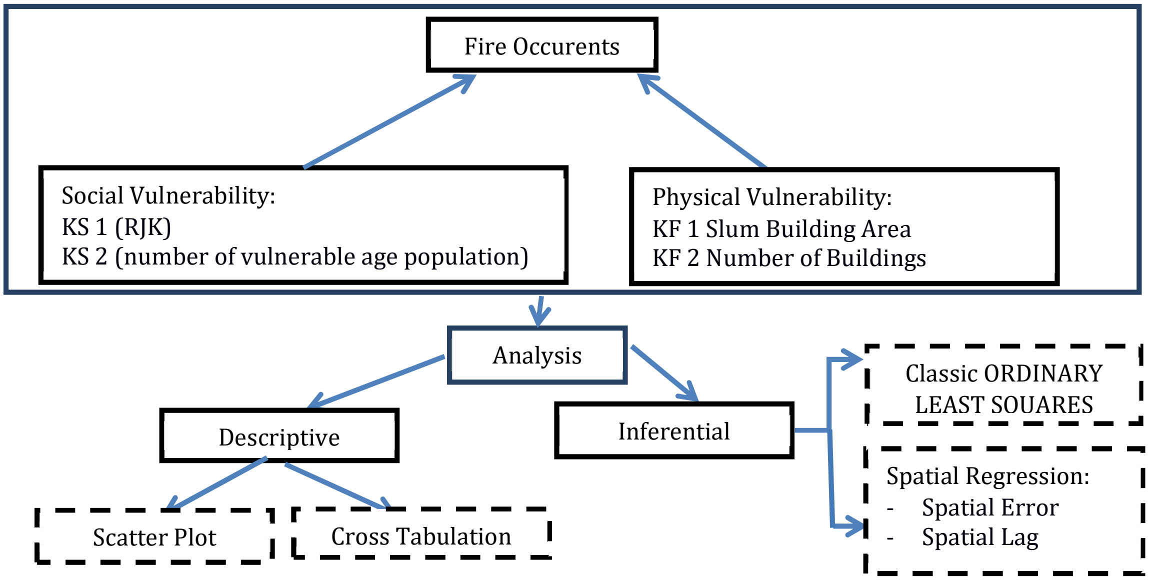

Figure 2. Research Analytics

Model specifications are described in several equations as follows:

(1) Classic Ordinary Least Squares (OLS) Model [17]: This method was used to determine the relationship between dependent and independent variables that acted as determinants of advanced spatial models through the Ordinary Least Square (OLS). The variable terms that can be used are R-squared 0.5 < x < 0.1 and = 10%. Classical regression has the following mathematical equation:

$$JML\_KBKRN = C + \beta_1 * RJK + \beta_2 * JML\_U\text{-}RTN + \beta_3 * LS\_BGN\_KMH + \beta_4 * JML\_BGN \quad (2)$$

Where:

JML_KBKRN = Fire occurrence in a sub-district
X1 = RJK = Sex Ratio in a sub-district
X2 = JML_U-RTN = Number of vulnerable age population (<5 years old and > 65 years old) in a sub-district
X3 = LS_BGN_KMH = Slum Building Area in a sub-district
X4 = JML_BGN = Number of Buildings of various functions in 1 neighborhood (sub-district)
C = Intercept / Constant
$\beta_1, \beta_2, \beta_3, \beta_4$ = Regression coefficient value

(2) Spatial Model [13]:

(1) $$JML\_KBKRN = C + \beta_1 * RJK + \beta_2 * JML\_U\text{-}RTN + \beta_3 * LS\_BGN\_KMH + \beta_4 * JML\_BGN + \lambda \text{ (Spatial Error)} \quad (3)$$

(2) $$JML\_KBKRN = C + \beta_1 * RJK + \beta_2 * JML\_U\text{-}RTN + \beta_3 * LS\_BGN\_KMH + \beta_4 * JML\_BGN + \rho \text{ (Spatial Lag)} \quad (4)$$

Where:

JML_KBKRN = Fire occurrence in a sub-district
RJK = Sex Ratio in a sub-district
JML_U-RTN = Number of vulnerable age population (<5 years old and > 65 years old) in a sub-district
LS_BGN_KMH = Slum Building Area in a sub-district

JML_BGN = Number of Buildings of various functions in a neighborhood (sub-district)
C = Intercept / Constant
$\beta_1, \beta_2, \beta_3, \beta_4$ = Regression coefficient value

3. Result and Discussion

When running Ordinary Least Squares (OLS) Regression, spatial weight matrix using inverse distance method. Number of observation 261, with 5 variables, the regression (OLS regression) results in GeoDa software show R-Squared of 0.374154 (which means robust or trusted 37,4%), variable is significant if P-value < 0.05. Result shown that all independent variable (RJK, JML_U-RTN, LS_BGN_KMH, JML_BGN) significant to dependent variable (JML_KBKRN) because P-value ≤ 0.05. Next diagnostics the significancy of Lagrange Multiplier (LM)-Error and Lagrange Multiplier (LM)-Lag (significant when P-value ≤ 0.05 or ≤ 0.1), result found that one them significant which is LM-Lag, then next step run spatial Lag Model.

Table 4. Classic regression results (OLS) from Ms Excel and GeoDa

Variables	Coefficient	Probability (P-Value)	Description	Summary
Constant	27.7264	0.00014	-	**R-Squared: 0.374154**
RJK	-0.259503	0.00034	significant	
JML_U-RTN	0.00032178	0.01101	significant	**Number of observation: 261**
LS_BGN_KMH	0.0177898	0.02402	significant	
JML_BGN	0.00033151	0.00013	significant	**Significant F: 4.3360235669611E-25**

Table 5. Diagnostics for spatial dependence

Test	Value	Prob (P-value)	Decision
Morans's I	1.2669	0.20518	Failed to reject H_0
Lagrange Muliplier (LM) Lag	2.6407	0.10416	Reject H_0
Robust LM (Lag)	1.8963	0.16849	Failed to reject H_0
Lagrange Multiplier (LM) error	0.9193	0.33766	Failed to reject H_0
Robust LM (error)	0.1749	0.67578	Failed to reject H_0
Lagrange Multiplier (SARMA)	2.8156	0.24468	Failed to reject H_0

Result for Spatial lag model shows R-Squared 0.380988 (which mean robust or trusted 38 %). Spatial Lag Model result that all independent variables, including sex ratio, are significant but have an inverse relationship with the dependent variable (number of fires). Surprisingly, the higher the sex ratio, the lower the number of fires, which contradicts the previously proposed theory regarding the correlation between the sex ratio and the risk of fire.

Table 6. Spatial Lag model regression Results

Variables	Coefficient	Probability	Description	Summary
W_JML_KBKRN	0.135057	0.13495		**R-Squared: 0.380988**
Constant	26.0904	0.00022	-	
RJK	-0.248258	0.00042	significant	**Number of observation : 261**
JML_U-RTN	0.000340589	0.00593	significant	
LS_BGN_KMH	0.0164116	0.03354	significant	**Likelihood Ratio Test**
JML_BGN	0.00028979	0.00163	significant	**Prob : 0.12928**

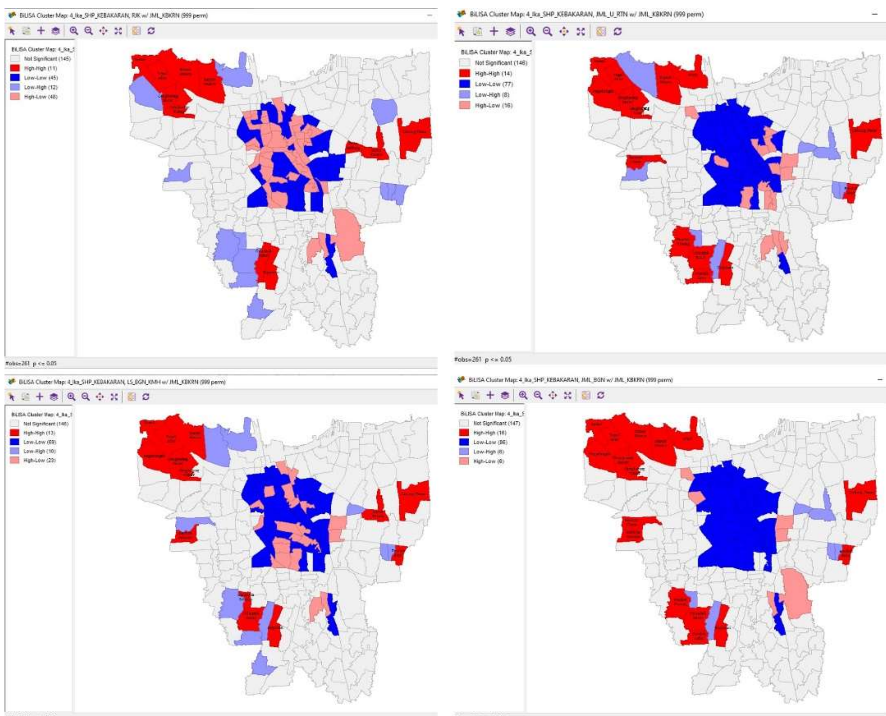

Figure 3. Bivariate analysis of Lisa Moran's I
Source: Data Process, 2023

The remaining independent variables, including the number of vulnerable age residents, the area of slum buildings, and the number of buildings, show a significant direct proportion to the dependent variable (number of fires). According to the theory proposed earlier, an increase in the value of each variable will also increase the risk of fire incidents. The regression results showed a significant value of 10% in the test results for the Lagrange multiplier (lag), hence the analysis continued with the spatial lag model regression process.

The correlation of relationships between regions was determined using the *queen contiguity* method with the histogram of relations used to visualize the neighboring regions. The number of observation areas, mean and median neighbors were 261, 13.7, and 12. Data correlation was conducted using Lisa cluster maps to determine the Neighborhoods that Group Directly Spatial from analysis Bivariate Lisa Moran's. This process increased the near Neighborhoods affected by variable Occurrences of Fire.

Spatial dependencies asses by Lisa Morans I Bivariate analysis, result showed that there were several clusters with *high-high* patterns grouped in urban villages, as indicated in the following table:

Table 7. High-high Pattern group from Lisa Morans I Bivariate results

VARIABLE	NUMBER OF CLUSTERS	NEIGHBORHOODS (SUB-DISTRICT)
Between Y (JML_KBKRN) and X1 (RJK)	3	Cluster 1: North Jakarta (Kamal Muara-Kapuk Muara) in groups with West Jakarta (Kamal, Tegal Alur, Cengkareng Barat, Cengkareng Timur) Cluster 2: East Jakarta (Rawa Terate-Pulo Gadung) Cluster 3: South Jakarta (Cilandak Timur-Ragunan)
Between Y (JML_KBKRN) and X2 (JML_U-RTN)	3	Cluster 1: North Jakarta (Pluit – Kapuk Muara) Cluster 2: West Jakarta (Kamal-Tegal alur-Pegadungan-Cengkareng Barat-Cengkareng Timur) Cluster 3: South Jakarta (Pondok Pinang-Cilandak Barat-Pondok Labu)
Between Y (JML_KBKRN) and X3 (LS_BGN_KMH)	2	Cluster 1: North Jakarta (Kamal Muara) in group with West Jakarta (Kamal-Tegal Alur-Pegadungan-Cengkareng Barat-Cengkareng Timur) Cluster 2: South Jakarta (Gandaria Selatan-Cilandak Barat)
Between Y (JML_KBKRN) and X4 (JML_BGN)	3	Cluster 1: North Jakarta (Pluit-Kapuk Muara-Kamal Muara) grouped with West Jakarta (Kamal-Tegal Alur-Pegadungan-Cengkareng Barat-Cengkareng Timur) Cluster 2: West Jakarta (Meruya Utara-Meruya Selatan) Cluster 3: South Jakarta (Pondok Pinang-Cilandak Barat-Pondok Labu)

Source: Data Process, 2023

To asses the correlation (clustering) between variables such as dependent (number of fires) and independent variables (sex ratio, vulnerable age, area of slum buildings, number of buildings) can use Bivarate Moran's I Scatter plot.

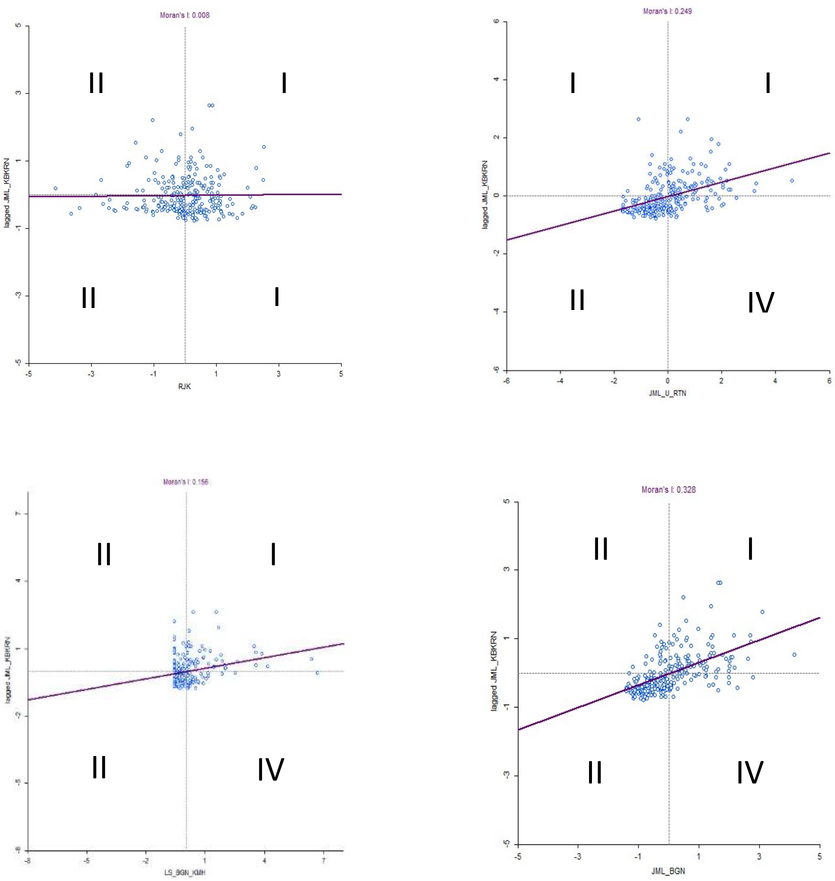

Figure 4. Correlation from Bivariate Moran's Scatter Plot betweek variables
Source: Data Process, 2023

Although the regression results showed significant results, when OLS spatial regression was used to test the data, both LM Lag and LM error did not show significant values because it was > 0.05 and in the range of < 0.1 for LM Lag, while LM error was at >0.5. Therefore, the fire incidents in Jakarta Special Capital Region do not have a spatial effect, which contradicts the processing of spatial data using Morans'I and Scatter Plot. This shows a correlation or clustering between the dependent (number of fires) and the independent variables (sex ratio, vulnerable age, area of slum buildings, and number of buildings).

4. Conclusion

In conclusion, fires in Jakarta Special Capital Region are caused by various factors such as economic, social, physical, and environmental vulnerability. In the social and physical vulnerability factors studied, significant classical regression results were obtained, where the variables of the number of vulnerable age population, slum building area, and number of buildings were significant and directly proportional to the dependent variable (number of fires). Furthermore, each increase in the value raises the risk of the number of fires, which is in accordance with the theory put forward regarding the correlation of several variables with the risk of fire. The opposite result was found in the sex ratio, which was significant and inversely proportional to the dependent variable (number of fires). This means that the higher the sex ratio, the lower the number of fires, which is different from the theory previously proposed on sex relations with the risk of fire. Meanwhile, spatially, the symptoms of fires in Jakarta Special Capital Region do not have spatial effects even though Lisa Morans I Bivariate and Lisa Moran's Scatter Plot show clustering between villages.

Recommendation

The analysis of spatial relationships between urban villages in Jakarta Special Capital Region provides valuable insights for the provincial government to minimize the potential for fires in the future. The clustering of villages identified in this study highlights the importance of regional planning, particularly in slum areas, to reduce population and building density and create more open spaces. This can help to minimize the spread of fires by allowing air to circulate and prevent fires from jumping between buildings. Infrastructure facilities such as passable roads, fire trucks, clean water sources, and hydrants should also be provided to support fire prevention and response efforts in the area.

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