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Property Crime in Java Island 2022 based on Demography and Socioeconomic Aspects using Spatial Analysis Approach

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Abstrak

Kejahatan terhadap hak milik/barang merupakan tindak pidana paling umum di Indonesia, dengan peningkatan tajam pada tahun 2022, yang menunjukkan urgensi untuk meneliti faktor-faktor demografi dan sosioekonomi pemicunya. Pulau Jawa, sebagai pusat ekonomi dan populasi terbesar, mencatat kenaikan tertinggi, mencapai 65,85% dibandingkan tahun sebelumnya dan menyumbang lebih dari sepertiga total kasus nasional. Kondisi ini mendesak perlunya pemahaman yang lebih mendalam tentang bagaimana kejahatan terhadap hak milik terkait dengan faktor sosial dan spasial, khususnya di Pulau Jawa, guna mengembangkan intervensi berbasis wilayah yang lebih efektif. Penelitian ini bertujuan untuk memberikan gambaran umum mengenai kejahatan properti dan variabel-variabel spasial yang memengaruhinya. Analisis dilakukan melalui metode deskriptif yang dilanjutkan dengan analisis inferensial, menggunakan pendekatan Regresi Binomial Negatif Terboboti Geografis, yang menghasilkan nilai AIC sebesar 1284,27. Hasil penelitian menunjukkan adanya empat kelompok wilayah dengan keterkaitan spasial, dengan angka harapan hidup dan rasio Gini muncul sebagai variabel signifikan di seluruh wilayah. Selain itu, variabel rata-rata lama sekolah dan jumlah penduduk juga memengaruhi sebagian wilayah, mencerminkan variasi pengaruh antarwilayah dalam konteks kejahatan terhadap hak milik/barang. Penelitian ini diharapkan dapat menjadi dasar untuk pengembangan kebijakan pencegahan kejahatan yang lebih efektif dan terarah.

Kata Kunci: kejahatan terhadap hak milik/barang, kriminalitas, analisis spasial, Pulau Jawa

Abstract

Property crime is the most common criminal offence in Indonesia, with a sharp increase by 2022, indicating the urgency to examine the demographic and socioeconomic factors driving it. Java, as the largest economic and population centre, recorded the highest increase, reaching 65.85% compared to the previous year and accounting for more than a third of the national total. This calls for a deeper understanding of how property crime is linked to social and spatial factors, particularly in Java, in order to develop more effective area-based interventions. This study aims to provide an overview of property crime and the spatial variables that influence it. The analysis was conducted through descriptive methods followed by inferential analysis, using the Geographically Weighted Negative Binomial Regression approach, which resulted in an AIC value of 1284.27. The results showed four groups of spatially linked regions, with life expectancy and Gini ratio emerging as significant variables across regions. In addition, the variables mean years of schooling and total population also affect some regions, reflecting the variation in influence between regions in the context of property crime. It is hoped that this research will provide a basis for the development of more effective and targeted crime prevention policies.

***Keywords**: property crime, criminality, spatial analysis, Java Island*

1 Introduction

Indonesia is one of the countries with a high crime index in Southeast Asia and even in the world. Indonesia along with Cambodia is ranked 20th out of 192 countries in the world or 2nd in Southeast Asia after Myanmar with an index of 6.85 points in 2023 or an increase of 0.48 points compared to the 2021 based on the release of the Global Organized Crime Index (2023) [1]. According to Sustainable Development Goals (SDGs) on Goals 16 “Peace, Justice, and Strong Institutions”, there are several goals that explain the importance of war on crime, violence, etc. The United Nations is committed to reducing crime rates around the world, especially in developing countries, such as Indonesia. This goal is aiming to create a sense of security and peace for the entire population.

Based on the publication of crime sourced from the Indonesian National Police in the first semester of 2022, there are three Regional Police that are consistently listed in the top five positions with the highest crime cases in Indonesia in January till June 2022. These include East Java Regional Police, Metro Jaya Regional Police, and West Java Regional Police. Not only that, in the span of six months, the most dominant crime that occurred was theft with aggravation, which is one type of property crime [2].

Property crime is one of the most prevalent types of crime in Indonesia. These crimes include theft, theft with violence, theft with firearms, theft with sharp weapons, ordinary theft, theft with aggravation, theft of motor vehicles, hoarding, arson with intent, and destruction of property. Based on data from the Indonesian National Police Criminal Investigation Agency in 2022, the number of cases of property crime in Java Island amounted to 31,353 cases, an increase of 12,247 cases or 65.85% compared to the previous year. The number of cases of property crime at the national level also increased by 16,590 cases from the previous year of 74,247 cases, to 90,837 cases in 2022 or an increase of 22.34%. The crime rate in an area is closely related to the demographic and socioeconomic factors behind it. Criminality in Indonesia is generally caused, among others, by the population factors of poverty, unemployment, and education [3]. Based on research conducted by [4], the low and still uneven level of education is one of the factors driving the crime of theft. Other factors that can affect criminal acts are psychological factors or internal factors [5]. Not only that, according to study conducted by [6], poverty and unemployment are the two main factors that encourage criminal acts. The factors of education, unemployment and poverty cannot be separated from each other because they are interrelated. The low level of education affects the increase in unemployment, which will result in a high poverty rate. These interrelated factors can then influence a person to commit criminal acts.

Meanwhile, based on the publication of Crime Statistics 2023 which is sourced from the registration data of the Indonesian National Police, the number of property crime in Java Island in 2022 accounted for a proportion of 33.37% of the total such crimes in Indonesia. Not only that, property crime is also the most common type of crime, amounting to 42.39% of the total crimes in Indonesia [7]. In addition, Java Island also occupies the second position for property crime, slightly different from Sumatra Island as shown in Figure 1 below.

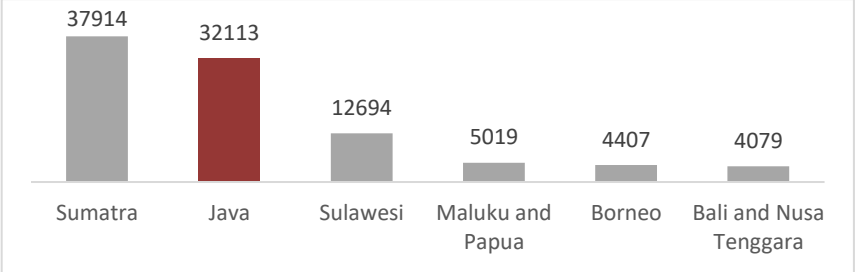

Figure 1. Property Crime in Major Island of Indonesia in 2022

The number of property crime cases in Java Island tended to decrease from year to year in the 2014-2021 period. However, there is an anomaly in the number of cases in 2022 which shows a significant increase in the number of cases as shown in the Figure 2 below. The rapid increase in the number of property crime in Java Island in 2022 is something that needs to be studied more deeply in this research.

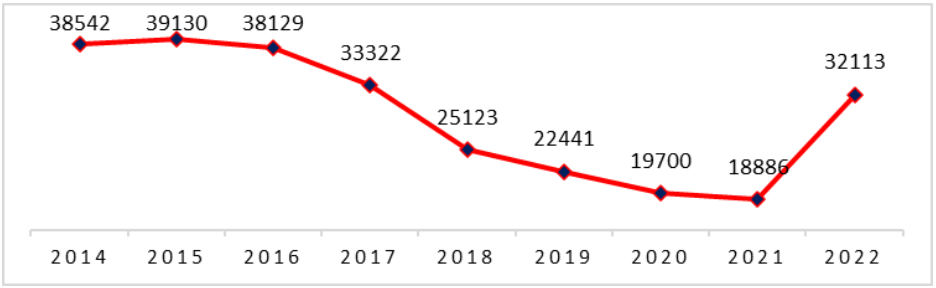

Figure 2. Property Crime in Java Island in 2014-2022

Besides that, Java Island was chosen as the research locus by the researchers because it has the second highest number of criminal offenses. In addition, [8] also argued that mobility by land in Java Island has also been quite good in connecting between regencies/cities, thus allowing inter-regional interaction. Not only that, crime cases on Java Island are generally more varied in terms of the motives behind them, as well as an increase in the quality and quantity of crime. Java is the most populous island in the world, and has a high population density. Research conducted by [9] shows that population density is positively correlated with crime in West Java Province, and can even trigger criminal acts. Java Island is also currently the center of government and economy in Indonesia. Not only that, the population of Java Island has diverse

ethnic, cultural and linguistic backgrounds. This also allows variations in the background of the criminal acts committed by the perpetrators.

Several previous studies have been conducted to find out what factors influence the occurrence of criminal acts, both qualitatively and quantitatively. However, there has been no research that focuses on property crime. Some research on crime that uses a spatial approach, among others, was conducted by [10] and [11] that use Geographically Weighted Regression (GWR) and [12] that use Geographically Weighted Panel Regression. In addition, there are also studies that use other analytical methods such as panel regression which conducted by [13], [14], and [15]. All of these studies mainly used socioeconomic variable as predictor variable. Significant variable that affects property crime varied among those studies. Variables that significantly affect crime include the poverty rate, mean years schooling, and gross regional domestic product [10]; male population, number of people moving in, percentage of teenagers, and number of Covid-19 incidents [11]; poverty rate, unemployment rate, gross regional domestic product at constant prices per capita, human development index, and mean years schooling [12]; unemployment rate and poverty rate [13]; unemployment rate, poverty rate, and population density [14]; education level and population density [15].

GWNBR has several advantages over other methods such as GWR, Geographically Weighted Panel Regression, and panel regression. First, GWNBR is more appropriate for spatial count data, such as the number of crimes or patients with certain diseases, because this model can overcome the high variability in count data that often occurs in the spatial context. Second, GWNBR has the ability to handle the overdispersion that often occurs in count data, which cannot be handled well by methods such as GWR and panel regression. In addition, this method also accounts for spatial heterogeneity, so that the estimation results are more consistent with the geographic characteristics of each location. Thus, GWNBR can provide more accurate and relevant results in spatial analysis involving count or event data.

This paper aims to know general overview, spatial effect on property crime cases in Java Island in 2022, also to know variables that affect them spatially.

2 Research Methods

2.1 Data

The unit of analysis used in this study includes 117 regencies/cities in Java Island in 2022. West Bandung Regency crime data was combined with Cimahi City crime data, and Pangandaran Regency crime data was combined with Banjar City crime data. This is because that two regencies do not yet have their own resort police stations, so their jurisdictions are still

incorporated with their parent regions. Response variable used in this study is the number of property crime that occur in each regency/city in Java Island in 2022 (Y). There are also 7 predictor variables, namely mean years of schooling (X_1), life expectancy (X_2), unemployment rate (X_3), poverty rate (X_4), Gini ratio (X_5), population density (X_6), and total population in hundred thousand (X_7). This study used secondary data sourced from Indonesian National Police Criminal Investigation Center and BPS-Statistics Indonesia. There are also latitude (v_i) and longitude (u_i) data of regent's and mayor's office from Google Maps.

2.2 Analysis method

This study used Geographically Weighted Negative Binomial Regression (GWNBR) that processed using R version 4.3.2 and QGIS version 3.22.3. The GWNBR method is taken because it can accommodate the presence of overdispersion in numerical data and the presence of spatial heterogeneity so as to produce a more suitable model, better and representative results and smaller errors.

Steps of inferential analysis conducted in this study are:

1. Non-multicollinearity assumption check.

   The first step taken in this study is checking non-multicollinearity assumption. This is done to determine the absence of a strong relationship between the predictor variables used. Multicollinearity can be detected by variance inflation factor (VIF) value. The assumption of non-multicollinearity is violated if there are one or more predictor variables that have a VIF value of more than 10. Variables that have a VIF value of more than 10 cannot be used in regression modeling.

2. Form a Poisson regression equation by including variables that fulfill the non-multicollinearity assumption as shown in Equation 1.

$$\ln(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 \qquad (1)$$

   with:

   Y : response variable

   β_0 : intercept

   $\beta_1, \dots, \beta_7$: coefficient regression of predictor variable $X_1, \dots, X_7$

3. Check the equidispersion assumption in the Poisson regression model.

   Checking the assumption of equidispersion can be done by looking at the deviance value of the model, if the deviance value is more than 1, then there is an indication of

overdispersion. A model that can accommodate overdispersion is negative binomial regression.

4. Form a negative binomial regression equation using variable that identically same with Poisson regression before as shown as Equation 2.

$$\ln(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 \quad (2)$$

with:

Y : response variable

β_0 : intercept

$\beta_1, \dots, \beta_7$: coefficient regression of predictor variable $X_1, \dots, X_7$

5. Check for spatial heterogeneity.

Spatial heterogeneity can be checked by using Breusch-Pagan (BP) test. Spatial heterogeneity presence if BP test shows p-value less than significance level that stated before. Model that can accommodate spatial heterogeneity is Geographically Weighted Negative Binomial Regression (GWNBR).

6. Choose an optimum bandwidth.

Bandwidth selection is done using Golden Selection Search by looking at two criteria, namely cross validation (CV) and the Akaike's Information Criterion (AIC).

7. Form a Geographically Weighted Negative Binomial Regression (GWNBR) using variable that identically same with negative binomial regression before as shown as Equation 3.

$$\begin{aligned}\ln(Y) = {} & \beta_0(u_i, v_i) + \beta_1(u_i, v_i)X_1 + \beta_2(u_i, v_i)X_2 + \beta_3(u_i, v_i)X_3 \\ & + \beta_4(u_i, v_i)X_4 + \beta_5(u_i, v_i)X_5 + \beta_6(u_i, v_i)X_6 + \beta_7(u_i, v_i)X_7\end{aligned} \quad (3)$$

with:

Y : response variable

β_0 : intercept

$\beta_1, \dots, \beta_7$: coefficient regression of predictor variable $X_1, \dots, X_7$

u_i : longitude of regent's office of regency/city i

v_i : latitude of regent's office of regency/city i

8. Simultaneous and partial testing of GWNBR model parameters.
9. Model interpretation
10. Model evaluation

3 Result and Discussion

3.1 Overview of Property Crime in Java Island in 2022

Figure 3 shows that there is a spatial distribution pattern of the number of property crime. The map shows that the darker the color of a regency/city, the higher the number of property crime in that area. It can be seen that there is a clustering of regencies/cities with a high number of property crime in the western and eastern parts of Java, while regencies/cities with a low number of property crime tend to cluster in the central part of Java. The highest number of property crime with 891 cases or more were in South Jakarta City, Bogor Regency, Cimahi City and West Bandung Regency, and Surabaya City.

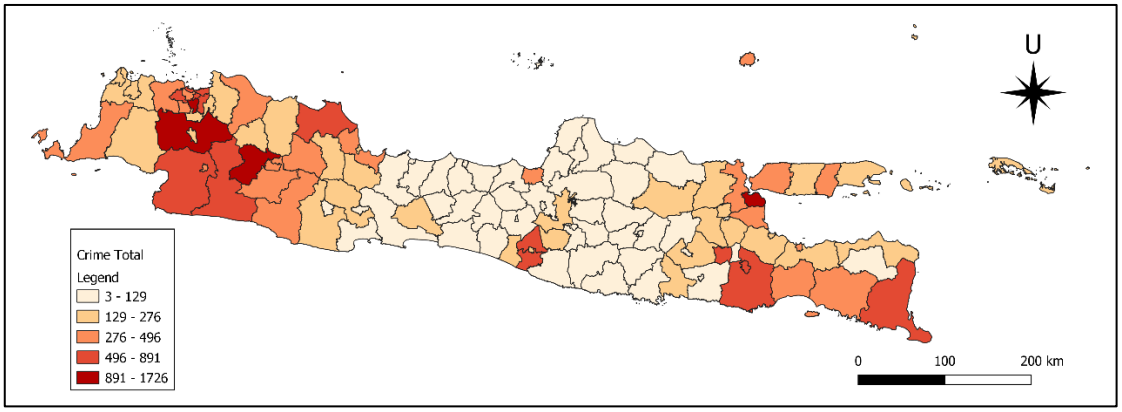

Figure 3. Map of Property Crime in Java Island in 2022

In 2022, the regency/city with the highest number of property crime was Surabaya City with 1,726 cases, while the regency/city with the lowest number of property crime was Kepulauan Seribu Regency with 3 cases. According to research conducted by [16], the high crime rate, especially theft with violence in Surabaya City, occurred due to several factors, including regional conditions, income, poverty, and unemployment coupled with the vast jurisdiction of the Surabaya Resort Police Station which covers 31 juridical areas. Meanwhile, the Kepulauan Seribu Regency area is in the form of islands which can make it difficult for criminals to commit their crimes.

3.2 Poisson regression modeling

Poisson regression is the simplest regression used to model response variables in the form of count data. Before modeling with Poisson regression, it is necessary to check the assumption of non-multicollinearity using the VIF value in multiple linear regression. The results of checking the assumption of non-multicollinearity are shown in table 1 below.

Table 1. VIF value for checking non-multicollinearity assumption

Variable	VIF	Decision
X_1	5.3729	Non-multicollinearity assumption is satisfied
X_2	1.3875	Non-multicollinearity assumption is satisfied
X_3	1.5501	Non-multicollinearity assumption is satisfied
X_4	2.5952	Non-multicollinearity assumption is satisfied
X_5	1.6600	Non-multicollinearity assumption is satisfied
X_6	2.5623	Non-multicollinearity assumption is satisfied
X_7	1.3634	Non-multicollinearity assumption is satisfied

Based on Table 1, it can be seen that there are no variables that have a VIF value of more than 10 so that all variables can be included in Poisson regression modeling. This also indicates that the assumption of non-multicollinearity is satisfied and no multicollinearity existed between predictor variable. After that, we can do Poisson regression modeling to determine variables that influence number of property crime in Java Island in 2022. Result of the Poisson regression modeling is shown in table 2 as follows.

Table 2. Poisson regression parameter estimation

Variable	$\widehat{\boldsymbol{\beta}}$	$se(\widehat{\boldsymbol{\beta}})$	Z_{score}	p-value
intercept	9.0550	0.1970	45.9580	<0.0001*
X_1	0.1374	0.0088	15.6960	<0.0001*
X_2	-0.0876	0.0029	-30.1290	<0.0001*
X_3	0.0351	0.0032	10.7080	<0.0001*
X_4	0.0162	0.0028	5.7930	<0.0001*
X_5	1.6420	0.1297	12.6650	<0.0001*
X_6	0.0000	0.0000	19.5760	<0.0001*
X_7	0.0408	0.0006	72.8760	<0.0001*

*significant at the level of significance (α) = 5%

Based on the results of modeling with Poisson regression in Table 2, all predictor variables reject H_0 at the 5 percent significance level. The variables that significantly affect the number of property crime include mean years schooling (X_1), life expectancy (X_2), unemployment rate (X_3), poverty rate (X_4), Gini ratio (X_5), population density (X_6), and total population (X_7). Equation 4 shows Poisson regression model that formed.

$$\ln(\hat{Y}) = 9.0550^{*} + 0.1374X_1^{*} - 0.0876X_2^{*} + 0.0351X_3^{*} + 0.0162X_4^{*} + 1.6420X_5^{*} - 0.0000X_6^{*} + 0.0408X_7^{*} \quad (4)$$

However, further checking of the equidispersion assumption required in the Poisson regression model is needed. Poisson regression is appropriate if the equidispersion assumption is satisfied where the variance and mean values are equal. The test carried out to check the

assumption of dispersion is the Pearson dispersion value. Beside of that, indication of equidispersion can be found on the mean and variance value of response variable. Table 3 below shows the results of testing the Pearson dispersion value also the mean and variance values of the Poisson regression model.

Table 3. Equdispersion assumption test

Test	Test Value	Decision
Comparison of mean and variance values	267.97 < 89,856.28	Overdispersion
Pearson dispersion value	154.3544	Overdispersion

Based on testing the assumption of equidispersion shown in Table 3, it can be seen that the mean value is much smaller than the variance value and the Pearson dispersion value is more than 1, indicating that there is overdispersion in the Poisson regression model. This indicates that the Poisson regression model is not suitable for modeling the number of property crime in Java Island in 2022. Therefore, regression modeling is needed that can accommodate overdispersion, namely negative binomial regression.

3.3 Negative binomial regression modeling

Overdispersion that occurs in the Poisson regression model indicates that the regression cannot be used in modeling so negative binomial regression is one of the alternative modeling that can be used. Table 4 below shows the results of testing the negative binomial regression modeling.

Table 4. Negative Binomial regression parameter estimation

Variable	$\widehat{\boldsymbol{\beta}}$	$se(\widehat{\boldsymbol{\beta}})$	Z_{score}	p-value
intercept	10.5200	2.0970	5.0140	<0.0001*
X_1	0.1655	0.0909	1.8210	0.0686
X_2	-0.1264	0.0292	-4.3360	<0.0001*
X_3	0.0402	0.0349	1.1530	0.2489
X_4	0.0267	0.0265	1.0070	0.3139
X_5	4.0670	1.5800	2.5740	0.0101*
X_6	0.0000	0.0000	1.0010	0.3167
X_7	0.0535	0.0084	6.3610	<0.0001*

*significant at the level of significance (α) = 5%

The deviance value obtained from the modeling is 125.57. This value is compared with the value of $\chi^2_{(0,05;7)} = 14.067$, so it can be concluded that with a significance level of five percent, there are one or more variables that have a significant effect on the number of property crime in Java Island in 2022. Based on the modeling with negative binomial regression in Table 4, there are three predictor variables reject H_0 at the 5 percent significance level. The variables

that significantly affect the number of property crime include life expectancy (X_2), Gini ratio (X_5), and total population (X_7). Equation 5 shows negative binomial regression model that formed.

$$\ln(\hat{Y}) = 10.5200^{*} + 0.1655X_1 - 0.1264X_2^{*} + 0.0402X_3 + 0.0267X_4 + 4.0670X_5^{*} + 0.0000X_6 + 0.0535X_7^{*} \quad (5)$$

The next examination that can be applied is spatial heterogeneity to determine the diversity of variables that affect property crime in each regency/city.

3.4 Spatial heterogeneity

The next examination that can be applied is spatial heterogeneity. Testing for spatial heterogeneity is important to identify differences in spatial characteristics that may occur between the observed regencies/cities. Differences in characteristics between the observed regencies/cities may lead to differences in regression parameters and variables that significantly affect the number of property crime in a regency/city in Java Island in 2022. Spatial heterogeneity testing uses the Breusch-Pagan test statistic. Table 5 below contains the results of the spatial heterogeneity test.

Table 5. Spatial Heterogeneity Test

Test	BP statistics	p-value	Decision
Breusch-Pagan	84.6548	<0.0001	Spatial Heterogeneity is existed

Based on Table 5, the Breusch Pagan statistic value is 84.6548 with a p-value of less than 0.0001. This indicates the existence of spatial heterogeneity in modeling the number of property crime in Java Island in 2022 with predetermined predictor variables. Thus, it can be concluded that at the 5 percent significance level, there is enough evidence to state that there is spatial heterogeneity that causes differences in regression parameters in each regency/city. One of the spatial regression models that can accommodate response variables in the form of count data, overdispersion, and spatial heterogeneity is Geographically Weighted Negative Binomial Regression (GWNBR).

3.5 Geographically Weighted Negative Binomial Regression (GWNBR) modeling

Determining the optimum bandwidth is important before the formation of the GWNBR model. The formation of the distance matrix is done by calculating the distance between the two regency/city coordinate points. The distance measure used in this study is the Euclidean distance. Meanwhile, bandwidth is one thing that is no less important in GWNBR modeling. The determination of bandwidth is also closely related to the determination of the kernel function

used. This study uses an adaptive bi-square kernel, because it can accommodate areas that are divided into separate islands well, for example the Kepulauan Seribu Regency and Madura Island. After obtaining the optimum bandwidth and distance matrix, a spatial weight matrix will be formed in the form of a symmetrical matrix with a size according to the number of regencies/cities observed, which is a matrix with a size of 117×117.

After selecting the optimum bandwidth, GWNBR modeling is performed. After that, a model similarity test was conducted. Model similarity testing aims to determine the difference in the use of GWNBR modeling with negative binomial regression modeling. The expected result of testing the similarity of the model is the difference between the GWNBR model and the negative binomial regression model. Based on the results of processing with RStudio, the results obtained are F_{score} of 1.0028. The critical point is the value F_{table} at a significance level of 5 percent is found to be $F_{(0.05;109,109)} = 0.7287$. So, the value obtained is F_{score} which is greater than F_{table}. Thus, it can be concluded that with a significance level of 5 percent, there is a significant difference between the GWNBR model and the negative binomial regression model, or in other words, the GWNBR model is better used than the negative binomial regression model.

After it is known that the GWNBR model is better used than negative binomial regression, simultaneous testing is carried out. Simultaneous testing aims to determine whether the variables used together have a significant effect on the number of property crime in Java Island in 2022 in the GWNBR model. In addition, simultaneous testing can also be used to see whether or not there is at least one variable that has a significant effect on the number of property crime in Java Island in 2022. Based on the processing data, the deviance value is 108.6983. The critical point is the value of the chi-square table at the 5 percent significance level, which is found to be equal to $\chi^2_{(0.05;7)} = 14.067$. So, the deviance value is greater than χ^2_{table}. Thus, it can be concluded that with a significance level of 5 percent, there is at least one predictor variable that significantly affects the number of property crime in Java Island in 2022, or in other words, all predictor variables simultaneously or together affect the number of property crime in Java Island in 2022 based on GWNBR model.

Partial significance was also conducted for testing aims to determine the predictor variables that significantly affect the number of property crime in each regency/city in Java Island in 2022. Table 6 below contains the predictor variables that significantly influence the number of property crime in each regency/city in Java Island in 2022.

Table 6. Significance variables in each regency/city

Group	Significant Variable	Regency/City
1	X_2 and X_5	Banyuwangi and Situbondo
2	$X_1, X_2,$ and, X_5	Kepulauan Seribu, Sukabumi, Pandeglang, Lebak, Tangerang, Serang, Tangerang City, Cilegon City, and Serang City
3	$X_2, X_5,$ and X_7	Cilacap, Banyumas, Purbalingga, Banjarnegara, Kebumen, Purworejo, Wonosobo, Magelang, Boyolali, Klaten, Sukoharjo, Wonogiri, Karanganyar, Sragen, Grobogan, Blora, Rembang, Pati, Kudus, Jepara, Demak, Semarang, Temanggung, Kendal, Batang, Pekalongan, Pemalang, Tegal, Brebes, Magelang City, Surakarta City, Salatiga City, Semarang City, Pekalongan City, Tegal City, Kulon Progo, Bantul, Gunung Kidul, Sleman, Yogyakarta, Pacitan, Ponorogo, Trenggalek, Tulungagung, Blitar, Kediri, Malang, Lumajang, Jember, Bondowoso, Probolinggo, Pasuruan, Sidoarjo, Mojokerto, Jombang, Nganjuk, Madiun, Magetan, Ngawi, Bojonegoro, Tuban, Lamongan, Gresik, Bangkalan, Sampang, Pamekasan, Sumenep, Kediri City, Malang City, Probolinggo City, Pasuruan City, Mojokerto City, Madiun City, Surabaya City, and Batu City.
4	$X_1, X_2, X_5,$ and X_7	South Jakarta City, East Jakarta City, Central Jakarta City, West Jakarta City, North Jakarta City, Bogor, Cianjur, Bandung, Garut, Tasikmalaya, Ciamis, Kuningan, Cirebon, Majalengka, Sumedang, Indramayu, Subang, Purwakarta, Karawang, Bekasi, Bogor City, Sukabumi City, Bandung City, Cirebon City, Bekasi City, Depok City, Cimahi City and West Bandung, Tasikmalaya City, and Banjar City and Pangandaran.

Based on Table 6, it can be seen that there are four groups of model combinations of variables that significantly affect the number of property crime in each regency/city in Java Island in 2022. Figure 4 below provides a visual depiction of the distribution map of variables that significantly affect the number of property crime in each regency/city in Java Island in 2022.

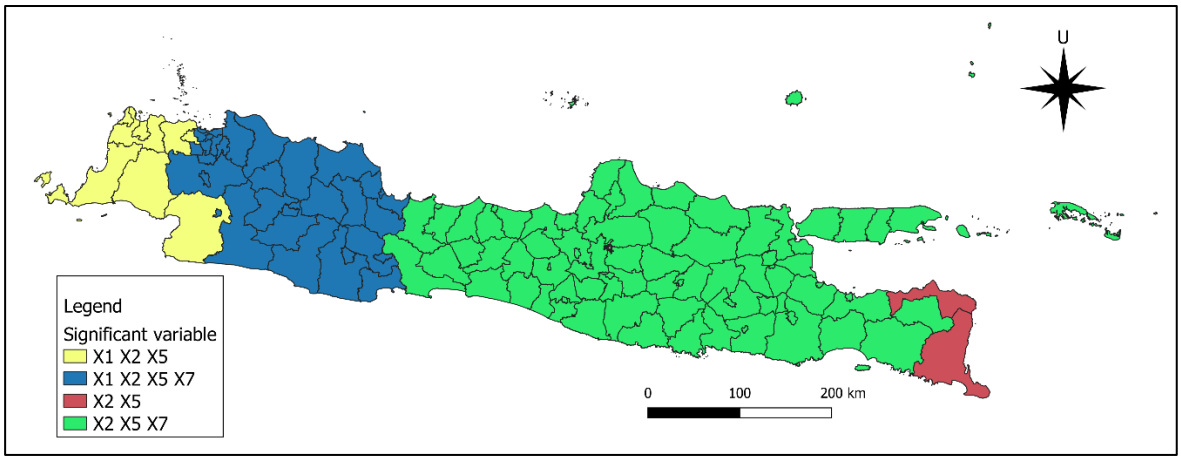

Figure 4. Map of the Distribution of Significant Variable that Affect Property Crime in Java Island in 2022

Figure 4 shows that there are four groupings of regencies/cities in Java Island based on variables that significantly affect the number of property crime in 2022. The western part of Java Island, namely most of Banten Province, except for South Tangerang City, plus Sukabumi and Kepulauan Seribu, is significant for the variables of mean years schooling (X_1), life expectancy (X_2), and Gini ratio (X_5). DKI Jakarta Province, except for the Kepulauan Seribu, and West Java Province, except for Sukabumi, are significant for the variables of mean years schooling (X_1), life expectancy (X_2), Gini ratio (X_5), and total population (X_7). The regions of Central Java Province, Yogyakarta Province, and East Java Province except Situbondo and Banyuwangi are significant to the variables of life expectancy (X_2), Gini ratio (X_5), and total population (X_7). The eastern end of Java Island, namely Situbondo and Banyuwangi is significant for life expectancy (X_2) and Gini ratio (X_7).

Based on this result, several significant variables in the model were found to be influenced by the characteristics of the surrounding area, reflecting the importance of the spatial context in understanding the phenomenon of crime. For example, life expectancy shows a significant influence, not only as a result of individual conditions, but also as a reflection of the surrounding social and economic environment. Areas with higher life expectancy tend to have better health facilities and stronger social support, all of which contribute to lower crime rates.

In contrast, the Gini ratio, which measures economic inequality, also shows a significant effect, with areas of high inequality tending to have higher crime rates. This is often triggered by conditions in neighboring areas; for example, if one area has a high poverty rate while the surrounding area is more affluent, dissatisfaction and frustration among the disadvantaged population may trigger crime, both as a form of social protest and to meet economic needs.

Based on partial significance testing, an example is taken as the formation of the GWNBR model, namely Surabaya City which is a regency/city that has the highest number of property crime in Java Island in 2022. Surabaya City is a regency/city with the 108th observation order with coordinate (u_{108}, v_{108}). The parameter estimation of GWNBR model for Surabaya City is presented in Table 7 below.

Table 7. Parameter Estimation of GWNBR Model in Surabaya City

Variable	$\widehat{\boldsymbol{\beta}}$	$\boldsymbol{Z_{score}}$
intercept	10.5147*	5,568.8150
X_1	0.2605	1.0606
X_2	-0.1407*	-4.0225
X_3	0.0048	0.0482
X_4	0.0390	0.5889

Variable	$\widehat{\boldsymbol{\beta}}$	$\boldsymbol{Z_{score}}$
X_5	4.0691*	880.3984
X_6	0.0000	0.2186
X_7	0.0846*	2.5504

*significant at the level of significance (α) = 5%

Based on Table 7, it can be seen that the significant variables in Surabaya City are life expectancy (X_2), Gini ratio (X_5), and total population (X_7). The GWNBR model equation formed in the regression parameter estimation of the number of property crime in Surabaya City in 2022 is as follows.

$$\ln(\hat{Y}) = 10.5147^{*} + 0.2605X_1 - 0.1407X_2^{*} + 0.0048X_3 + 0.0390X_4 + 4.0691X_5^{*} + 0.0000X_6 + 0.0846X_7^{*} \quad (6)$$

3.6 Model interpretation

After model formation using GWNBR, the model can be interpreted. In this section, we will interpret the GWNBR model formed for Surabaya City as in equation 6.

An increase in the mean years schooling (X_1) by one percent will increase the number of property crime by $\exp(0.2605) = 1.2976$ times in Surabaya City with the assumption that other variables are constant. This can occur because Surabaya City is the second largest metropolitan area in Indonesia which certainly has a fairly good level of education, indicated by a fairly high average length of schooling of 10.51 years. In other words, the average population aged 25 years and over in Surabaya City has studied up to grades 10 to 11 of secondary high school/equivalent. Along with the increase in the quality of education, in this case represented by the mean years schooling, it shows that there are high employment opportunities for formal jobs in the region. Jobs in the formal sector generally offer higher wages or salaries than jobs in the informal sector. This can be one of the triggers or driving factors in a criminal in committing a crime, especially in the type of property crime. This is in line with research conducted by [17] which shows the results that education has a positive significant relationship with crime in the Special Region of Yogyakarta Province. In line with this research, research conducted by [18] which shows that a high level of education in the Middle East Ring Road (MERR) area, Sukolilo District, Surabaya City, significantly affects the number of crimes that occur. The fundamental difference between the results of this study and that study is that in this study the relationship between the two is positive but not significant.

In the variable of life expectancy (X_2), it is found that an increase in life expectancy by one percent will reduce the number of property crime in Surabaya City by $\exp(-0.1407) = 0.8687$ times with the assumption that other variables are constant. This can occur because an increase in

the quality of health in Surabaya City is followed by an increase in the quality of life and reduces the desire from within or the temptation that comes from mentally to commit a crime. This is also evidenced by the high life expectancy in Surabaya City compared to other regencies/cities in Java Island in 2022, which amounted to 74.47 years. In addition, good health quality will also reduce the internal motivating factors of an individual to commit criminal acts, especially against property. The results of this study are also in line with research conducted by [19] and [20] which shows that good health quality will also affect the ability of better self-control, so as to minimize the intention to commit a crime. This study also shows that the relationship between life expectancy variables has a significant negative effect on the number of property crime in Surabaya City in 2022.

Meanwhile, one percent increase in the unemployment rate variable (X_3) will increase the number of property crime in Surabaya City in 2022 by $\exp(0.0048) = 1.0049$ times with the assumption that other variables are constant. This can occur because the higher prevalence of unemployment in an area will lead to new social problems, including the emergence of intentions or desires to fulfill their economic needs in various ways, one of which is illegally, namely by committing criminal acts. This is also in line with research conducted by [16] who stated that the difficulty of employment and the resulting increase in the prevalence and number of unemployed people in Surabaya City also increased the number of crimes, especially theft with the aim of meeting the needs of everyday life. In line with this, [21] argues that the increase in the number of violent theft crimes in the Surabaya Police Jurisdiction is partly due to the increasing unemployment factor. However, the open unemployment rate is one of the variables that does not significantly affect the number of property crime in Java Island in 2022. Based on research held by Hooghe et al., a high unemployment rate leads to an increase in the number of cases of crimes against property [22]. Beside of that study, similar study also conducted to determine the fluctuation of the crime rate caused by unemployment on a multilevel basis. Based on this research, it was found that high unemployment has more impact on property crime such as robbery, theft, and motor vehicle theft than violent crime [23]. In line with this, the National Crime Information Center Criminal Investigation Agency in its 2022 Journal Publication noted that criminals in 2022 were dominated by private employees, followed by farmers/fishermen/traders, then students. Criminals who are unemployed are only in the fifth highest rank [24].

Then, poverty rate (X_4) which increases by one percent will increase the number of property crime in Surabaya City in 2022 by $\exp(0.0390) = 1.0398$ times with the assumption that other variables are constant. This happens because poverty is one of the most fundamental

socioeconomic indicators because it can be the root of other social problems. High poverty in an area can cause a person to commit property crime to fulfill their daily needs, because their income is considered insufficient to finance expenses for their daily needs. Poverty rate in Surabaya City in 2022 also tends to be quite low compared to other regions in Java Island, which is 4.72 percent. High poverty levels can have a greater socioeconomic impact, one of which is triggering crime [25]. This is also in line with research conducted by Flango and Sherbenou which states in their book that one of the most important variables that can explain interregional crime rates is poverty [26]. Patterson on their book also revealed that there is a relationship between crime rates and aggregate economic conditions. Community crime is also commonly associated with absolute poverty and relative poverty. Crimes that are closely related to poverty are violent crimes, such as robbery [27]. In addition, high levels of poverty can also increase crime rates in surrounding areas. Based on the results of research conducted by [21] which states that the increase in the poor population is one of the causes of the increase in the crime rate in Surabaya City. However, based on the results of this study, it was found that the poverty rate did not significantly affect the property crime in Java Island in 2022.

In addition, a one percent increase in the Gini ratio (X_5) will increase the number of property crime in Surabaya City in 2022 by $\exp(4.0691) = 58.505$ times with the assumption that other variables are constant. This can occur because the inequality of expenditure between economic classes can cause social jealousy. The existence of social jealousy can trigger the intention or encouragement of residents who are in a low economic expenditure class to commit a crime on residents who belong to a higher economic expenditure class. In addition, inequality in expenditure also has an impact on social conflict which can later lead to criminal acts. The Gini ratio of Surabaya City is included in the medium classification class, which is 0.388. Even so, this figure is quite high when compared to other regencies/cities in Java. The results of this study are linear with the results of research conducted by [28] on economic inequality and security stability in Surabaya City. The results show that economic inequality results in security stability disturbances, such as urban social problems, one of which is crime. Research conducted by [27] shows that one of the dominant factors affecting crime is income inequality. High income inequality in a region can lead to an increase in the number of criminal offenses in the region and its neighbors. [22] also conducted a study on the effect of income inequality on crime. Based on this study, it was found that income inequality has a positive and significant influence on property crime, but has a negative impact on violent crime. In line with this research, this study also shows that the relationship between the Gini ratio variable has a significant positive effect on the number of property crime in Surabaya City in 2022.

In the variable of population density (X_6), it is found that a one percent increase in the variable has an impact on increasing the number of property crime in Surabaya City by $\exp(2.10 \times 10^{-5}) = 1.000021$ times with the assumption that other variables are constant. This can occur because areas with high population density tend to increase the potential for crime. The population density in Surabaya City in 2022 is 8,595 people/km^2 or it can also be interpreted that in every one square kilometer, there are 8,595 people living in the area. This figure is quite high considering that Surabaya City is also one of the metropolitan cities in Indonesia. Similar research was conducted by [28] and showed that one of the factors that also increased the crime rate in Surabaya City was population density. In line with this research, [16] also said that the condition of a dense area can allow the occurrence of street crime, one of which is theft. Even so, the research conducted by the author shows that the population density variable has a positive but insignificant effect on the number of property crime in 2022 on the island of Java.

The last predictor variable used in this study is total population (X_7). Every one percent increase in population will increase property crime in Surabaya City in 2022 by $\exp(0.0846) = 1.0882$ times with the assumption that other variables are constant. This can occur because the higher population in a regency/city will increase the opportunity for criminal acts to occur. The increasing population in an area can also result in an increasingly diverse community with different backgrounds and different intentions and goals. This allows for the emergence of evil intentions to commit crime in a person. The population of Surabaya City in 2022 is 2.8 million people and is the fourth most populous regency/city in Java Island in 2022, after Bogor Regency, Tangerang Regency, and East Jakarta City. According to research conducted by [18] which took a locus in the Middle East Ring Road (MERR) area, Sukolilo District, Surabaya City, it shows that new settlements characterized by an increase in population in an area will result in criminal potential and crime that increases along with the increase in the number of people living in the area. In addition, research conducted by [29] showed that the increasing population also had a positive and significant effect on the number of criminal offenses in Tangerang City. This can occur due to tighter competition between residents in fulfilling their needs.

Taken together, these results suggest a pattern where the social and economic conditions in an area can influence property crime rates, both directly and through influences from the surrounding environment. This pattern supports the need for policies that consider spatial and socio-economic factors in addressing crime, particularly in areas that exhibit high vulnerability to inequality, high unemployment, and high total population.

3.7 Model evaluation

After modeling the number of property crime in Java Island in 2022 using the Geographically Weighted Negative Binomial Regression (GWNBR) method, then the best model used can be evaluated. The measure of model goodness used in this study is Akaike's Information Criterion (AIC). Table 8 below contains a comparison of the AIC values of the Poisson regression, negative binomial regression, GWNBR.

Table 8. Comparison of AIC values among models

Model	AIC
Poisson Regression	15,137.37
Negative Binomial Regression	1,471.22
Geographically Weighted Negative Binomial Regression	**1,284.27**

Based on Table 7, it is found that the model with the smallest AIC value is the GWNBR model. It shows that the GWNBR model is the most suitable and best model that can be used in modeling the number of property crime in Java Island in 2022.

4 Conclusion

Based on the results and discussion described in the previous chapter, the following conclusions are drawn:

1. The distribution of the number of property crimes in Java Island in 2022 shows a clustering pattern in some areas. Regencies/cities with a high number of property crime are generally close to regencies/cities with similar characteristics, as are regencies/cities with a low number of property crimes. DKI Jakarta Province, Banten Province, West Java Province, Yogyakarta Province, and the eastern part of East Java Province have high rates of property crime. Meanwhile, Central Java Province and the western part of East Java Province have a low number of property crime offenses.
2. There is spatial heterogeneity in modeling the variable number of property crime in Java Island in 2022 against the independent variables used. This causes differences in regression parameters in each observed regency/city caused by differences in variables that significantly affect the number of property crime in that regency/city.
3. The best modeling of the number of property crime based on demographic and socioeconomic aspects in Java Island in 2022 is by using the GWNBR model. The modeling resulted in four groupings of regencies/cities based on variables that significantly influenced the number of property crime in those regencies/cities in 2022. In addition, there are

variables that significantly influence the number of property crime in all regencies/cities in Java Island in 2022, namely life expectancy and Gini ratio.

4. Future research in modeling the number of property crime or other types of crimes can be carried out with a unit of analysis in the form of a jurisdictive area to be more representative. However, it is still quite difficult to find independent variables that use jurisdictive areas, because sometimes jurisdictive areas are not the same as administrative areas.
5. Future research can develop the analysis of this research from other perspectives, for example from the perspective of criminology or sociology by using the demographic and socioeconomic variables used in this study, because it can provide insight or a broader picture of the causes of criminals in a regency/city in committing their crimes.
6. The police and local government can review the policies or actions taken in accordance with the characteristics of each regency/city. In addition, different special policies are needed, especially according to the significant variables in the regency/city, to reduce the occurrence of criminal acts, especially property crime. The police (especially at the resort police level) can map the areas within the regency/city that are prone to property crime, especially in areas that have a high mean years schooling, low life expectancy, high inequality of population expenditure, and a high population of an area. This can be done as a preventive effort for the occurrence of criminal acts, especially property crime.

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