Investigating Spatial Correlation Between COVID-19 Incidence and Poverty in Klaten Regency, Central Java

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Abstract. A health and financial crisis has been brought on by the COVID-19 pandemic. The tight restrictions put in place to stop the COVID-19 virus have affected and limited economic activity, resulting in a drop in per capita income and an increase in the population of the poor. This research aims to analyze the spatial pattern of COVID-19 incidence and poverty in the Klaten Regency and to examine the spatial correlation between COVID-19 incidence and poverty in the Klaten Regency. The study utilizes available secondary data and employs the Moran Index with the Queen Contiguity weighting matrix as the data processing technique. The data are analyzed using the Univariate Moran's I and Bivariate Moran's I test with the GeoDa software. The results show that the spatial pattern of confirmed COVID-19 cases in the Klaten Regency is clustered, as is the spatial pattern of the quantity of poor people in the same region. Furthermore, the spatial correlation between the quantity of confirmed COVID-19 cases and the quantity of poor people in the Klaten Regency is negative (I = -0.063) and (I = -0.151), indicating that the high or low value of confirmed COVID-19 cases in the Klaten Regency does not resemble the value of poverty in the same region. Therefore, to address the increasing poverty in the Klaten Regency, a comprehensive vaccination program should be implemented in every sub-district to handle COVID-19, and data on the eligible poor population for social assistance due to the pandemic should be updated.

Keywords: Spatial autocorrelation, Bivariate Moran's, COVID-19, Poverty.

1 Introduction

The 2019 coronavirus, also known as COVID-19, was spotted in Wuhan, China, at the end of December 2019 and spread globally to almost all over the world [1]. The COVID-19 pandemic caused health and economic crises [2,3]. The health crisis occurred because many populations were infected with COVID-19, so the level of human health decreased, which resulted in death [4,5]. In addition, the lockdown, one way to tackle the transmission of the COVID-19 virus, caused the economic crisis. Lockdown is the locking of all human activities, and it is recommended to stay at home [6]. For example, African countries implemented strict lockdowns [7], and India enforced national lockdowns [8], which resulted in an economic crisis.

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Striving to restrain the propagationof the COVID-19 virus in various countries, as well as social distancing and health protocols [9]. These efforts affected the limited economic activities of the community. Starting from companies that reduce the quantity of employees due to decreased company turnover impact bad labour market results [10]. Small and medium micro-businesses, for example, in the tourism sector, where visitors are quiet [11], impact decreasing income. The future economic downturn and uncertainty due to the COVID-19 pandemic [12] pose risks for investors. For example, the economic confidence index in Turkey has decreased from 97.5 to 91.8 [13]. The dismissal of most employees requires the population to change professions to make an impact on the difficulty of finding work to the point where there is an increase in the quantity of unemployed.

This incident resulted in a decline in the economic level [14] because the country's low per capita income, which has become narrower, impacts increasing poverty. Based on research conducted by [15], it is said that a decrease in per capita income has a substantial influence on increasing the poor population. Poverty is a condition in which one cannot meet the necessities of life, starting from clothing, food, and boards, because one does not have a job that guarantees life.

The COVID-19 pandemic significantly impacted the economy, resulting in a negative impact on income and an increase in poverty [16]. As in Sri Lanka, the COVID-19 pandemic has influenced the macro and micro-economy, which harms GDP and employment and has the potential to result in increased incidences of poverty [17]. Moreover, the COVID-19 virus is spreading globally, affecting global poverty as well, which is a danger to development efforts because it is influenced by the calamity, which emphasizes income and consumption shortages with aspects of human welfare [18].

Indonesia is also a country with a high poverty rate, and there has been an increase in the poor population during the COVID-19 pandemic. According to data from BPS 2021, in March 2021, the poor population in Indonesia was 27.54 million. In the area of Klaten Regency, Central Java, the percentage of the poor population in 2021 increased by 0.6% from 2020, with the portion initially being 12.89% to 13.49%. Therefore, the spatial distribution of the COVID-19 virus and the poor population is essential in determining regional development strategies against poverty during the COVID-19 pandemic [19]. Therefore, the purpose of this study is to examine the spatial distribution of validated COVID-19 cases and the poor population in the Klaten Regency as well as the spatial relation between these two variables.

2 Method

2.1 Research Location

The research location is Klaten Regency, one of Central Java Province's regencies, further divided into 391 villages and ten sub-districts. The district capital is Klaten, which include three districts: North Klaten, South Klaten, and Central Klaten. On Wednesday, 30 June 2021, Klaten was in first place with the most cases of COVID-19 in Central Java Province. In addition, Klaten is listed as among the ten districts with the highest poverty rate in Central Java (Fig 1).

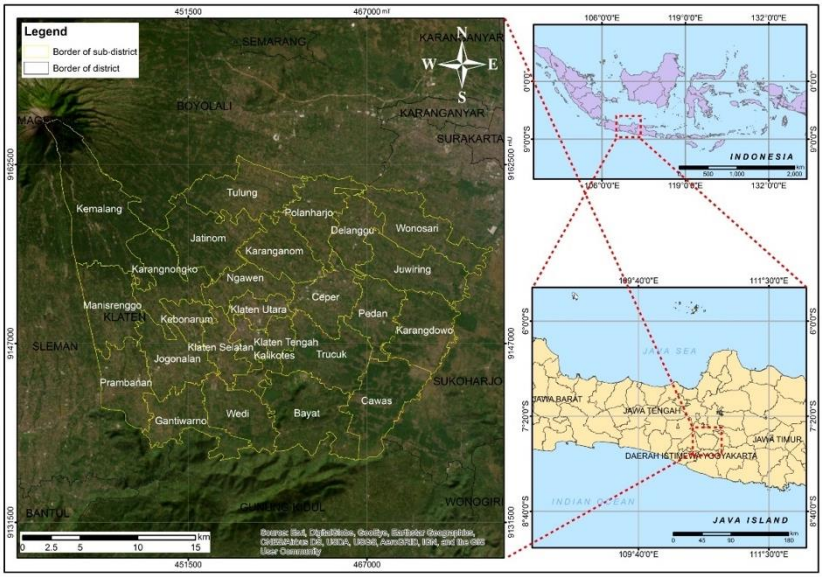


Fig. 1. Research Location

2.2 Data Sources

This research is observational, that is, by observing previously available data. Data from the Social Service and the Health Service of Klaten district government were utilized to compile the secondary data, which included information on the quantity of poverty-stricken residents and the quantity of verified COVID-19 cases. The ensuing graph depicts the quantity of verified COVID-19 cases in Klaten Regency. Fig 2 presents data on confirmed COVID-19 cases, indicating an increase in the quantity of cases since 2021 compared to the previous year.

In 2020, the highest number of COVID-19 cases was reported in Wonosari District, while the lowest number was recorded in the Kemalang District. However, in 2021, there was a significant increase in the quantity of cases, with Jogonalan District reporting the highest number of confirmed COVID-19 cases and Kemalang District reporting the lowest. As a consequence of the COVID-19 incident, the amount of populations in poverty has increased [20]. Klaten Regency also experiences this trend. The following is the quantity of poor populations in the Klaten Regency.

The poor population in Klaten Regency experienced an escalated between 2020 to 2021 when the COVID-19 pandemic began. Fig 3 shows the increase in the quantity of poor populations in Klaten Regency.

The area with the largest number of poor populations is Trucuk District. Meanwhile, the area with the smallest number of poor populations is Kebonarum District. In addition, the data needed in this research is the shape data of the administrative boundaries of Klaten Regency obtained from Inageoportal.

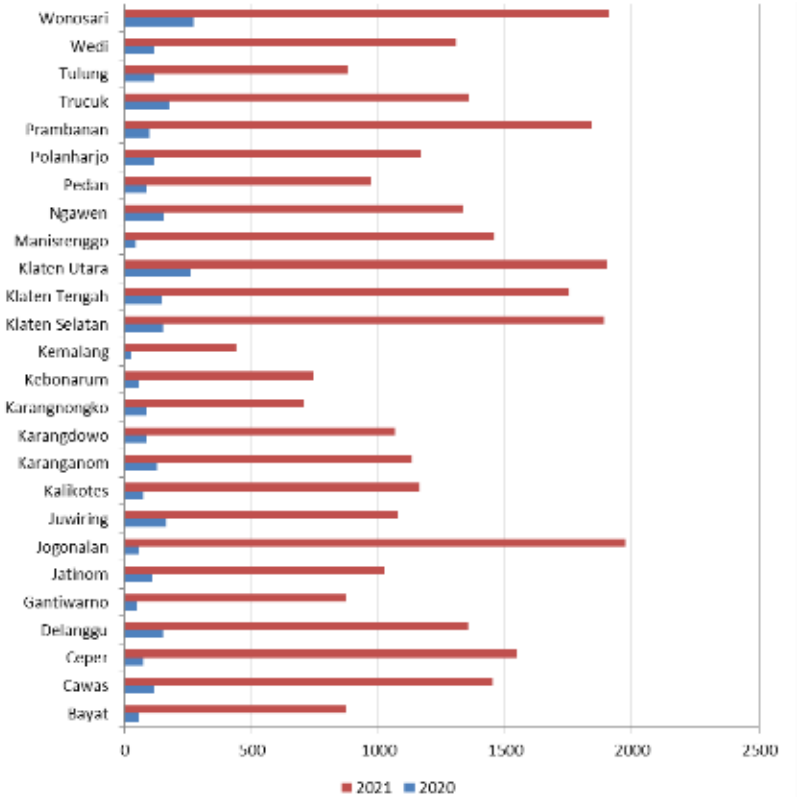


Fig. 2. Number of confirmed cases of COVID-19 in Klaten Regency (Source: Klaten District Health Office, 2021)

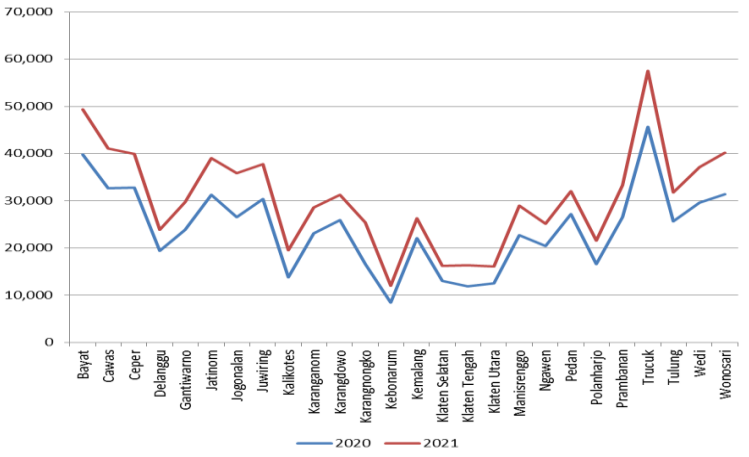


Fig. 3. Number of Poor Population in Klaten Regency (Person) (Source: Klaten District Social Service, 2021)

2.3 Data Analysis

In this study, we examine the spatial correlation between the quantity of confirmed COVID-19 cases and the quantity of poor populations in the Klaten Regency.The data processing method uses GeoDa software with the Moran Univariate Index test and the Moran Bivariate Index, based on the Queen Contiguity matrix weighting method by considering the intersecting sides and angles.

The Moran Univariate Index method is a Moran Index test that includes variables individually. Univariate Moran's I to analyze the distribution pattern of the quantity of confirmed cases of COVID-19 and the poor population. A positive Moran's I test value means a positive autocorrelation and vice versa. The Moran's I index value is between -1 and 1 to determine the distribution pattern. The value $-1 < I < 0$ demonstrate a negative spatial autocorrelation, while $0 < I < 1$ demonstrate a positive autocorrelation. Identify more patterns using the criteria if the value of $I > E(I)$ = clustered, if $I < E(I)$ = spread, and if $I = E(I)$ = spread unevenly. The value of E(I) is the estimated value of I, which is formulated as follows [21].

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

Information: n = the quantity of regions (districts in one district)

Moran Bivariate Index method is a Moran index test that uses two variables to identify the spatial correlation between the quantity of COVID-19 cases at the observation site and the quantity of poor populations residing in areas around the observation so that it will produce a positive or negative correlation. If the result I = positive, then one variable's high (low) value is surrounded by the other variables' high (low) value. If the result I = negative, then one variable's high (low) value is surrounded by the other variable's low (high) value. The researchers used Moran's Scatterplot for further analysis in this study to perceive the relation between standardized observed values and the standardized, average value of nearest neighbours [21].

The first of Moran's four quadrants, labeled "High-High," displays regions with high observation values covering areas with high observation values. Quadrant II (Low-High) shows a low observation value area surrounded by high observation value areas. Areas with low observation values are shown in Quadrant III (Low-Low), which is bordered by areas with high observation values. Areas with high observation values are encircled by low observation value areas in Quadrant IV (High-Low). Positive autocorrelation is typically found in quadrants I and III of the regions. Areas in quadrants II and IV, on the other hand, frequently exhibit negative autocorrelation values.

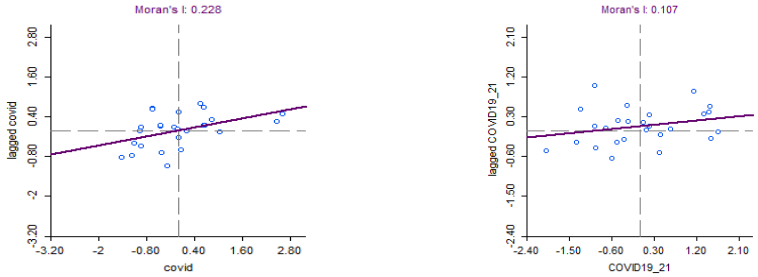
3 Result and Discussion

3.1 Spatial Pattern of the COVID-19 Confirmed Cases in Klaten Regency

Moran's univariate test was carried out to determine the spatial pattern of each research variable by producing an I value of Moran's Scatterplot. Pattern identification uses the following criteria: If the value of $I > E(I)$ = grouped pattern. If $I < E(I)$ =, the pattern

spreads. If I = E(I) = the pattern spreads unevenly, the value of E(I) is obtained from the calculation: $\frac{-1}{(n-1)} = \frac{-1}{(26-1)} = \frac{-1}{(25)} = -0.04$.

Univariate Moran's scatterplot test on the quantity of confirmed cases of COVID-19 in 2020 and 2021 shows that the total distribution of confirmed cases of COVID-19 in Klaten Regency is clustered because the Moran Index value is greater than the E(I) value (Fig 4).



(a) Year 2020 b) Year 2021

Fig. 4. Univariate Moran's Scatterplot Number of COVID-19 Cases (Source: Processed Secondary Data, 2022)

The spatial pattern of the confirmed cases of COVID-19 in Klaten Regency is clustered, which indicates that one sub-district has a similar value, or the confirmed cases of COVID-19 between sub-districts in Klaten are correlated with each other. The study yields similar results to the research conducted by [22], which states that "the Moran index number is greater than the E(I) number, so the COVID-19 case variable in DKI Jakarta has a clustered pattern". There is a positive spatial autocorrelation in the quantity of COVID-19 cases in Klaten Regency, meaning that if one sub-district has many confirmed cases of COVID-19, adjacent sub-districts also have confirmed cases of COVID-19. Fig 5 depicts the distribution map of confirmed COVID-19 cases.

Most areas with the highest confirmed cases of Covid-19 have high population densities. Like North Klaten District, which has a dense population, the surrounding areas also have high confirmed cases of Covid-19, namely Trucuk District, Central Klaten District, South Klaten District, and Ngawen District. Comparable, the research conducted by [23] also stated that apositive spatial relation exists between population density and the risk of COVID-19 in Makassar City, Pale Pale, and Palopo. However, high population density is not a factor that plays the most role in spreading the Covid-19 virus if you have better accessibility and infrastructure, as research conducted by [24] states that "population density is not the primary role in the spread of the Covid-19 virus. Therefore, the researchers concluded that the highest population density tended to have the highest cases of Covid-19 among other districts.

The confirmed cases of COVID-19 in both 2020 and 2021 exhibited a clustered pattern in the North Klaten, Central Klaten, South Klaten, Jogonalan, and Prambanan Districts. These districts showed a high incidence of COVID-19 due to their location as

connecting routes between other cities. This condition is due to collector roads and railroads connecting to other cities and regencies, leading to a continuous influx of residents and crowded conditions. Thus, the spread of Covid-19 continues to increase in the region. In addition, because the centre of Klaten city is in the Central Klaten District and most of the land use is buildings or settlements with a high population, Covid-19 spreads quickly. Therefore, it causes positive cases of Covid-19 to increase significantly. Therefore, it is necessary to add to the Covid-19 vaccination program in the area so that the spread of Covid-19 does not become more rampant.

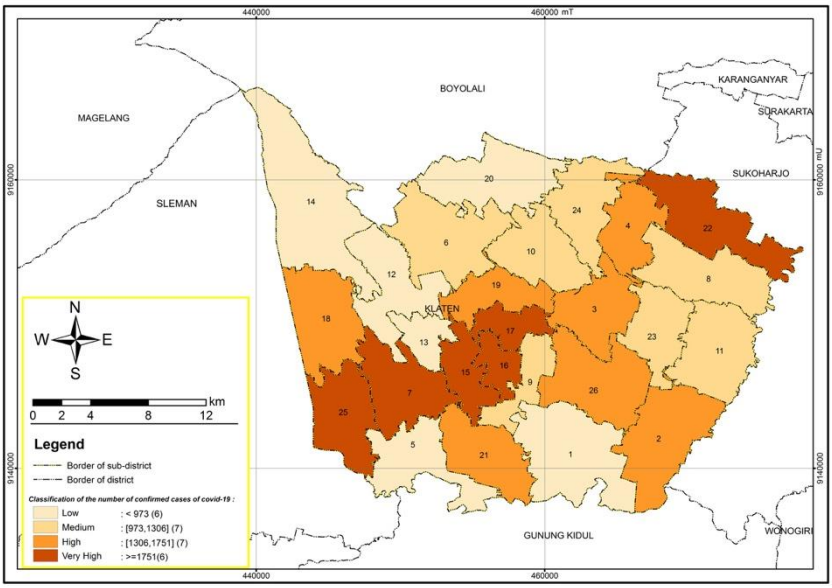
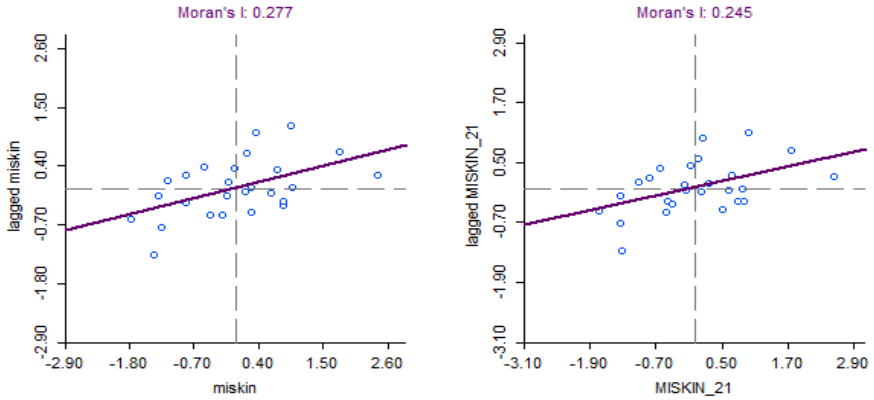


Fig. 5. Map of the confirmed cases of COVID-19 in Klaten Regency in 2021

3.2 Spatial Pattern of the quantity of Poor Population in Klaten Regency

Univariate Moran's scatterplot test shows that the I value for the variable number of poor populations in 2020 is 0.277, greater than the E(I) value of -0.04. The univariate moran's scatterplot test results show that the value I for the variable number of poor populations in 2021 indicates that the value I for the varying number of poor populations in 2021 is 0.245. This value is more significant than E(I) = -0.04. So, the distribution pattern of the poor in the Klaten Regency is clustered. The results of the 2020 and 2021 tests show that the distribution pattern of the poor in the Klaten Regency is spatially clustered. The Univariate Moran index test with the Moran Scatterplot for the poor can be seen in Fig 6.



(a) Year 2020 (b) Year 2021

Fig. 6. Univariate Moran's Scatterplot Number of Poor Population (Source: Processed Secondary Data, 2022)

The variable number of poor populations in 2020 and 2021 produces a positive Moran index value, indicating a spatial autocorrelation of the quantity of poor populations from one adjacent location, both in the year 2020 variable and in the year 2021 variable. These results align with the research conducted by [25], which states that "there is a spatial autocorrelation relation for poor households in Central Java Province because the results of Moran's index values show positive and significant." Therefore, the univariate Moran's scatterplot test results in this study were positive. Consequently, a spatial autocorrelation exists in the quantity of poor populations within Klaten Regency. Figures 7 illustrate the distribution map of the poor in Klaten Regency for 2020 and 2021.

Univariate Moran's I test shows a positive spatial autocorrelation and spatially clustered data on the quantity of poor populations in the Klaten Regency. However, research conducted by [26] also stated that "the Moran's index or what is known as Global Moran only shows spatial autocorrelation in Bengkulu City poverty data and clusters spatially". In a related study by [27], spatial autocorrelation was discussed, which suggests that "poverty in West Java Province exhibits positive spatial autocorrelation, indicating a clustering of poverty levels in certain regions." This implies that the difference in poverty levels between regions is not necessarily proportional to the distance between them, and vice versa (Fig 7).

Based on these results, it is known that the distribution pattern of the quantity of poor populations in Klaten Regency from the 2020 and 2021 data is clustered, indicating that one sub-district has similar values or the poor among sub-districts in Klaten are correlated with each other. The clustering pattern for a high class is located in Trucuk and Bayat Districts. Spatially, the pattern is formed based on adjacency between regions; because Trucuk Subdistrict is adjacent to Bayat Subdistrict, the quantity of poor populations is interconnected. Meanwhile, the low population is grouped in the central region, the city centre of Klaten Regency.

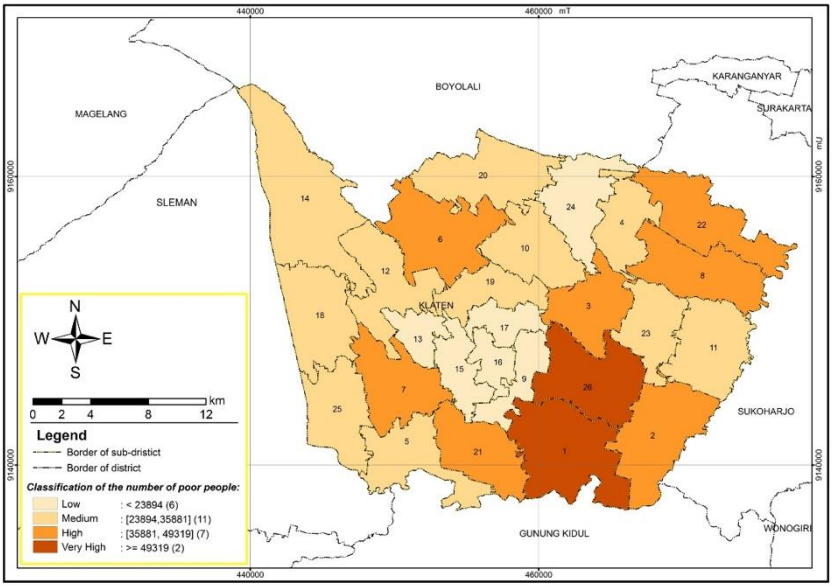


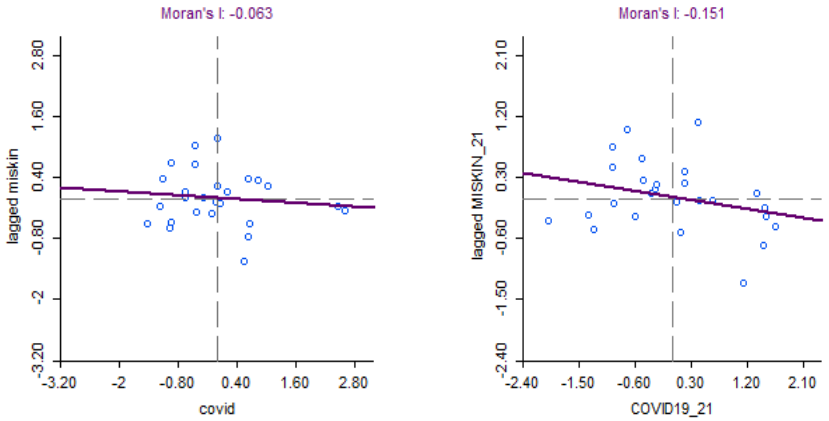
Fig. 7. Map of the quantity of poor population distribution in Klaten Regency in 2021

Residents in downtown areas will have a higher income than areas on the city's outskirts because most economic activities occur in the city centre, such as jobs in cities that require a lot of human resources. Judging from the land use, most of the Trucuk and Bayat sub-districts are paddy fields, meaning that most of the population earns a living as farmers. Thus, it affects the results of low income and makes the region poor. Therefore, areas with a high percentage of poor population need attention so that there are no social inequalities between regions in Klaten Regency. One of the factors for the increase in the quantity of poor populations in Klaten Regency is the existence of the COVID-19 pandemic. Therefore, updating data on the poor and vulnerable populations who deserve social assistance is necessary. There is a need to increase the social assistance budget and expand the quantity of beneficiaries to residents who have fallen into poverty on account of the COVID-19 pandemic.

3.3 Spatial Correlation of Covid-19 Confirmed Cases with the quantity of Poor Population in Klaten Regency

The measure of spatial correlation is the Moran Scatterplot statistic on the Moran Bivariate Test. Based on research conducted by [28] states that If a systematic pattern exists in the spatial dispersion of an attribute, one can conclude that there is a spatial correlation in the value of that attribute. A positive spatial correlation appears if an adjacent distance has a very comparable value, but if the values in adjacent areas are not comparable, a negative correlation appears. A value of 0 indicates no spatial correlation.

The results of the research on Moran's bivariate test discuss the relation between the two research variables, namely the spatial correlation between the variable number of confirmed cases of Covid-19 and the variable number of poor people in Klaten Regency. Moran's Scatterplot consists of the x-axis and y-axis. The quantity of confirmed cases of covid19 is the x-axis, and the quantity of poor people is the y-axis—the results of the Moran Bivariate Scatterplot test for data for 2020 and 2021. Fig 8 explains four quadrants: I, II, III, and IV.



(a) Year 2020 (b) Year 2021

Fig. 8. Bivariate Moran's Scatterplot of the Confirmed COVID-19 Cases with the quantity of Poor Population in Klaten (Source: Processed Secondary Data, 2022)

The position of quadrant I, or High - High (HH), is located at the top right and shows that sub-districts surround sub-districts with several confirmed cases of COVID-19 with a high number of poor populations. Quadrant II, or Low–High (LH), is located at the top left and shows that sub-districts with a low number of confirmed cases of COVID-19, however, are surrounded by sub-districts that have a high number of poor populations.

Quadrant III, or Low-Low (LL), is located at the bottom left and shows the sub-district, which has the sum. Low confirmed cases of COVID-19 are surrounded by sub-districts with a low number of poor populations too. Quadrant IV, also known as High–Low (HL), is located at the bottom right. Quadrant IV shows that sub-districts with a high number of confirmed cases of COVID-19, however, are surrounded by a low number of the poor population. The cluster of Bivariate Moran's Scatterplot results for the 2020 variable can be seen below. Table 1 presents the negative spatial correlation between the quantity of COVID-19 cases and the poor population in Klaten Regency for the year 2020.

Table 1. Cluster Moran's Bivariate Results Scatterplot of the quantity of COVID-19 Confirmed Cases with the quantity of Poor Population 2020

Clusters	Subdistrict
Quadrant I High-High (HH) [COVID-19 High-Poor High]	Delanggu, Juwiring, Karanganom, Trucuk
Quadrant II Low-High (LH) [COVID-19 Low-Poor High]	Bayat, Cawas, Low, Changwarno, Kalikotes, Karangdowo, Pedan, Polanharjo, Prambanan
Quadrant III Low-Low (LL) [COVID-19 Low-Poor Low]	Jatinom, Jogonalan, Karangnongko, Kebonarum, Kemalang, Manisrenggo
Quadrant IV High-Low (HL) [COVID-19 High-Poor Low]	South Klaten, Central Klaten, North Klaten, Ngawen, Wedi, Wonosari, Tulung

Source: Processed Secondary Data, 2022

It also indicates that the influential sub-districts tend to cluster in quadrants II and IV. The bivariate Moran's scatterplot test results (I = -0.063) demonstrate that areas with high (low) values of confirmed COVID-19 cases are surrounded by areas with low (high) values of the varying number of poor populations. The table below displays the results of the Bivariate Moran's Scatterplot cluster analysis for the variable in 2021. Table 2 shows that the spatial correlation between the quantity of COVID-19 cases and the poor population in Klaten Regency in 2020 is negative and indicates that influential sub-districts tend to be in quadrants II and IV.

Table 2. Cluster Results of Bivariate Moran's Scatterplot between the Variable Number of Confirmed Cases of COVID-19 and the Variable Number of Poor Populations in 2021

Clusters	Subdistrict
Quadrant I High-High (HH) [COVID-19 High-Poor High]	Cawas, Delanggu, Prambanan, Trucuk
Quadrant II Low-High (LH) [COVID-19 Low-Poor High]	Bayat, Ganwarno, Juwiring, Kalikotes, Karanganom, Karangdowo, Pedan, Polanharjo
Quadrant III Low-Low (LL) [COVID-19 Low-Poor Low]	Jatinom, Karangnongko, Kebonarum, Kemalang, Tulung
Quadrant IV High-Low (HL) [COVID-19 High-Poor Low]	Ceper, Jogonalan, South Klaten, Central Klaten, North Klaten, Manisrenggo, Ngawen, Wedi, Wonosari

Source: Processed Secondary Data, 2022

The results of the bivariate Moran's scatterplot test (I = -0.151) indicate that in the eight districts in quadrants II and IV, as well as in nine districts including quadrant IV, there is a negative spatial correlation between the quantity of confirmed cases of COVID-19 and the quantity of the poor population. This means that high (low) COVID-19 cases tend to be surrounded by low (high) values of poverty in these areas.

The results of this study align with the findings of [29], albeit using different variables, stating that "spatial correlation using bivariate moran's produces a negative spatial correlation between first aid delivery variables and neonatal death." Therefore, the

equation at the end of the study is a negative spatial correlation. Thus, the Klaten Regency area has a negative spatial correlation, where most areas are in quadrants II and IV. Judging by unit, for data for 2020 and 2021, Bayat District is included in quadrant II, meaning Bayat District has few confirmed cases of COVID-19. Hence, the surrounding area has a high number of poor populations. Because Bayat District has a low population and most of the land is paddy fields with hilly topography, there is minimal possibility of economic activity. The low population caused the small spread of the COVID-19 virus. Thus, the low COVID-19 score in Bayat District does not resemble the high poverty rate of the population around the Bayat District area. Compared to previous research using different variables, a study conducted by [30,31] states that "spatially, the Sao Paulo Regency with the highest incidence of COVID-19 is surrounded by high-density household districts living in slum areas too". Based on this statement, there is a relation with the results of this study, where the slum area is where the majority of the poor live. Central Klaten District is in quadrant IV, which means that Central Klaten has a high number of confirmed cases of COVID-19, so the surrounding area has a low number of poor populations. Because Central Klaten District is the city centre of Klaten Regency, it creates crowds, making it easy for the COVID-19 virus to spread. However, the high COVID-19 score in Klaten Tengah District does not have the same value for the poor in the surrounding area; the quantity of poor populations is low.

However, several districts are in quadrants I and III. Trucuk Sub-district is in quadrant I, which means that Trucuk Sub-District has a high number of confirmed cases of COVID-19, so the surrounding area of the sub-district has an increased number of poor populations as well. Because Trucuk District is one of the sub-districts in Klaten Regency with a high population percentage, the COVID-19 virus will quickly spread from crowds of residents due to population density. The quantity of confirmed cases of COVID-19 is high in Trucuk District, so the surrounding areas also have a similarly high number of poor populations. Kemalang Subdistrict is in quadrant III, which means that Kemalang Subdistrict has a low number of confirmed cases of COVID-19, so the area around the area also has a low population. Kemalang District is a sub-district in Klaten Regency with a low population. In addition, seen from land use, most of the Kemalang District area is non-paddy land because the morphology and temperature of the area are very supportive for use as fields and plantations. Low population density makes it difficult for the COVID-19 virus to spread. The confirmed cases of COVID-19 in Kemalang District are at a low level. The value of the confirmed cases of COVID-19 is similar to that of the poor population in the vicinity, namely the low poor population.

The Bivariate Moran's Scatterplot result is negative, meaning the spatial correlation is negative. Based on these results, it can be obtained that the high and low scores of confirmed cases of COVID-19 in the Klaten Regency area do not resemble the scores of poor populations in the surrounding areas. Therefore, modern technology is also needed to handle COVID-19 [32] through self-detection only at home and vaccination programs to prevent the spread of COVID-19. Furthermore, the COVID-19 pandemic has affected slow economic activity and increased poor populations [33,34,35]. From

this, globally, the spatial correlation of COVID-19 cases with poor populations is negative, which means that areas with high confirmed cases do not necessarily mean that the surrounding areas have a high number of poor populations. From these results, it is necessary to collect specific data on which areas have an increase in the poor population due to the co-19 pandemic and the need to distribute social assistance. In addition, the vaccination program must also be carried out for every area in Klaten Regency, especially for areas with high cases of COVID-19. Thus, support from the Government and the surrounding community is significant in developing the Klaten Regency area. Therefore, a healthy Klaten community revives economic activities to decrease the poor population.

4 Conclusion

The research results lead to the conclusion that there is a clustered spatial pattern in the quantity of confirmed cases of COVID-19 and the quantity of poor populations in Klaten. The spatial correlation between the quantity of confirmed cases of COVID-19 and the quantity of poor populations in Klaten is negative. Moran's univariate index results show that the spatial pattern of the quantity of confirmed cases of COVID-19 in the Klaten Regency is clustered, and the spatial pattern of the quantity of poor populations in the Klaten Regency is clustered. Because Moran's index value results are more significant than the expected value of E(I), clustering means that there is spatial autocorrelation, namely districts with many confirmed cases of COVID-19 surrounded by areas with an increased number of confirmed cases of COVID-19. Areas surround communities with a high number of poor populations and a high number of poor populations.

The spatial correlation between the quantity of confirmed cases of COVID-19 and the poor population in the Klaten Regency area is negative. Because the Moran Bivariate test results on the Moran Scatterplot show the results I = -0.063 and I = -0.151. The majority of areas are in quadrants II and IV. So, to deal with increasing poverty in Klaten Regency, it is necessary to tackle the COVID-19 virus by employing a comprehensive vaccination program in all areas of the Klaten Regency. Therefore, a healthy Klaten community will revive economic activities to decrease the poor population. Therefore, we suggest that the Klaten Regency Government prioritize overcoming increasing poverty during the COVID-19 pandemic by focusing more on areas with dense populations and high poverty rates.

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