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Spatial Pattern Analysis of the Distribution of Public Secondary Schools in Metro City, Lampung Province

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Abstract: *This study aims to analyze the spatial pattern of the distribution of public junior high schools (SMP) in Metro City as a basis for evaluating equitable access to education in urban areas. A quantitative approach was used with the Nearest Neighbor Analysis (NNA) method based on Geographic Information Systems (GIS). School location data was obtained from the Education Office and field mapping results, then analyzed using ArcGIS 10.8 software to calculate the spatial distribution index (T). The results showed that the 10 public junior high schools in Metro City were spread across five subdistricts with an even distribution pattern (T value = 1.8). These schools were generally located around collector road networks and residential centers, indicating a strong correlation between the location of educational facilities and factors of accessibility and population density. These findings indicate that local government policies have taken into account the principle of spatial justice in the provision of educational services. GIS-based spatial analysis has proven to be effective in evaluating the equitable distribution of educational facilities and can be used as a basis for planning new schools in potentially developing suburban areas. This study emphasizes the importance of integrating spatial planning and educational policy to achieve sustainable access equity.*

Keywords : *Spatial Patterns; Junior High Schools; Educational Equity; Nearest Neighbor Analysis; GIS*

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Abstrak: *Penelitian ini bertujuan untuk menganalisis pola spasial persebaran Sekolah Menengah Pertama (SMP) Negeri di Kota Metro sebagai dasar evaluasi pemerataan akses pendidikan di wilayah perkotaan. Pendekatan kuantitatif digunakan dengan metode analisis tetangga terdekat (Nearest Neighbor Analysis / NNA) berbasis Sistem Informasi Geografis (SIG). Data lokasi sekolah diperoleh dari Dinas Pendidikan dan hasil pemetaan lapangan, kemudian dianalisis menggunakan perangkat lunak ArcGIS 10.8 untuk menghitung indeks distribusi spasial (T). Hasil penelitian menunjukkan bahwa 10 SMP Negeri di Kota Metro tersebar di lima kecamatan dengan pola distribusi merata (nilai T = 1,8). Sekolah-sekolah tersebut umumnya berlokasi di sekitar jaringan jalan kolektor dan pusat permukiman, menunjukkan keterkaitan kuat antara lokasi fasilitas pendidikan dengan faktor aksesibilitas dan kepadatan penduduk. Temuan ini mengindikasikan bahwa kebijakan pemerintah daerah telah memperhatikan prinsip keadilan spasial dalam penyediaan layanan pendidikan. Analisis spasial berbasis SIG terbukti efektif dalam mengevaluasi pemerataan fasilitas pendidikan, serta dapat digunakan sebagai dasar perencanaan pembangunan sekolah baru di kawasan pinggiran yang berpotensi berkembang. Penelitian ini menegaskan pentingnya integrasi perencanaan spasial dan kebijakan pendidikan untuk mencapai pemerataan akses yang berkelanjutan.*

Kata Kunci : *Pola Spasial; Sekolah Menengah Pertama; Pemerataan Pendidikan; Nearest Neighbor Analysis; SIG*

Introduction

The spatial pattern of public junior high school distribution is a complex phenomenon involving various social, economic, and geographical factors. Research on the distribution of educational facilities in various cities has become highly relevant, especially in the context of educational planning and social justice. In Metro City, as in many other cities, equitable access to education is a central issue that affects the quality of education and opportunities for students.

Metro City is one of the cities in Lampung Province with an area of approximately 68.74 km² and a population of around 170,000 (BPS Kota Metro, 2024). Based on data from the Education and Culture Office, there are 19 public junior high schools (SMPN) spread across five subdistricts. However, the distribution of these schools is not entirely even, especially when viewed from the population density in each subdistrict. This raises an important question about the extent to which the distribution of educational facilities in Metro City reflects the principle of equitable access to education.

According to Jiang et al. in Chengdu, rapid population growth has a significant impact on the distribution of school facilities, highlighting the importance of spatial analysis in understanding this pattern (Jiang et al., 2024). In the context of Metro City, the distribution pattern of schools is not only influenced by geographical location but also by underlying social factors. Hamnett and Butler argue that distance and school distribution can reinforce existing social segregation, making it important to understand how school location affects accessibility for certain community groups (Hamnett & Butler, 2013). This suggests that uneven school planning can exacerbate social injustice, given that schools often reflect the social diversity of their surroundings.

Spatial analysis also shows that the existence of educational facilities can be influenced by the characteristics of the social environment surrounding the school. For example, Kwate and Loh show that environmental characteristics play an important role in student nutrition, related to the existence of fast food restaurants near schools (Kwate & Loh, 2010). This shows the importance of considering health and environmental aspects in research on school distribution. In this context, the distribution pattern of schools in Metro City is likely influenced by local factors that can impact student health and academic success.

The influence of ethnic heterogeneity on education spending also has an important impact. Ajilore shows that ethnic diversity in an area can affect spending on education, which can influence the quality of education that students receive (Ajilore, 2011). This indicates the need for a more in-depth analysis of how ethnic and social diversity can affect access to education in Metro City.

Still in the realm of educational accessibility, Buttenheim et al. highlight how social grouping can affect student health (Buttenheim et al., 2012). Although this relates to health, it shows the relationship between access to education and student safety in the context of facilities available around schools. In research related to the influence of the surrounding environment, Barboza emphasizes the importance of analyzing student safety in the context of violence (Barboza, 2018). This type of research is relevant to Metro City, where

environmental planning and student safety are highly dependent on the public space around schools.

On the other hand, variations in educational outcomes show that not all educational environments are created equal. Smith et al. note that there are spatial inequalities in educational outcomes, highlighting the importance of distribution maps to understand the quality of education in different areas (Smith et al., 2018). This highlights the need for careful mapping when planning school locations in Metro City, taking into account the aspects that create inequality.

Ellaway et al. examined the presence of fast food outlets near schools located in socially disadvantaged areas, revealing a cluster between food environments and schools (Ellaway et al., 2012). This reinforces the argument that the school environment should be considered as an educational location and is closely related to student health aspects. Gao et al., through an analysis of public facility accessibility, noted the importance of accessibility to urban growth (Gao et al., 2020). In the context of Metro City, an analysis of the areas surrounding educational locations can help formulate better management strategies to achieve equal access to education.

Overall, spatial analysis of school distribution must capture social dynamics and local contexts. The use of Geographic Information Systems (GIS) in this study, as emphasized by Denice, can provide a clearer picture of how social and demographic shifts affect the placement of schools (Denice, 2022). GIS offers powerful tools for visualizing data and performing complex analyses, enabling education planners to make more informed decisions about the location and desired features of schools.

Method

This study used a quantitative approach with spatial analysis methods. This approach was used to examine the distribution patterns of public junior high schools in Metro City objectively based on spatial data and geographical coordinates. Quantitative analysis allowed researchers to measure the spatial relationship between school locations and determine the pattern of distribution, whether it *is clustered*, *random*, or *uniformly* distributed. The research was conducted in Metro City, Lampung Province, which consists of five subdistricts: Metro Pusat, Metro Barat, Metro Timur, Metro Selatan, and Metro Utara. Metro City was chosen because it had a diverse population density and distribution of educational facilities between regions. This research was conducted in 2025 with a focus on data from active schools in the 2024/2025 academic year.

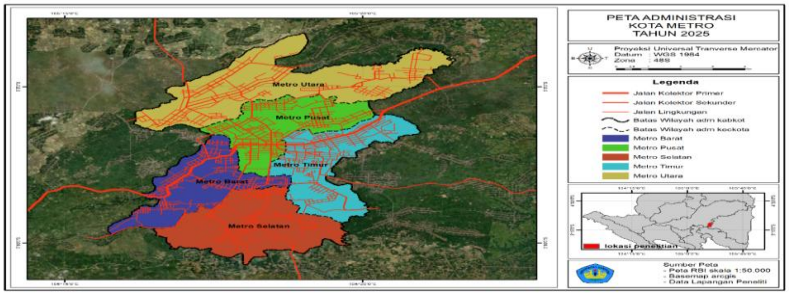

Figure 1. Administrative Map of Metro City in 2025

Data and Data Sources

The data used consists of:

1. Spatial data in the form of the location coordinates of public junior high schools in Metro City obtained from *the Geographic Information System (GIS)*, *Google Earth*, and *the Central Statistics Agency (BPS)*.
2. Non-spatial data includes the number of schools, number of students, and population density data per subdistrict from *the Metro City Education and Culture Office* and *the Metro City Statistics Agency*.
3. The administrative base map of Metro City was obtained from *BIG (Geospatial Information Agency)* for the georeferencing process.

Data was collected through documentation and spatial digitization techniques. School locations were identified using *Google Earth* and then converted to shapefile (.shp) format using ArcGIS 10.x software. All location points were then projected in the UTM Zone 48S coordinate system for more accurate spatial analysis results. Spatial pattern analysis was performed using the **Nearest Neighbor Analysis (NNA)** method to determine the distribution pattern of public junior high schools in Metro City.
The NNA formula is as follows:

$$R = \frac{D_o}{D_e}$$

where:

- R= Nearest Neighbor Index
- D_o= Average distance between actual school points
- D_e= Expected average distance in a random pattern

Criteria for interpreting results:

- $R < 1$: **Clustered** distribution pattern
- $R = 1$: **Random** distribution pattern
- $R > 1$: **Uniform distribution** pattern

D_o s are calculated by finding the average closest distance between each school, whileD_e s are calculated using the equation:

$$D_e = \frac{1}{2\sqrt{(n/A)}}$$

where$n$ is the number of schools and$A$ is the study area (km²).
The analysis process was carried out using ArcGIS or QGIS software with the *Average Nearest Neighbor (ANN)* feature to obtain the R index value and its significance test (Z-score and p-value).

Results and Discussion

This study aimed to analyze the spatial pattern of the distribution of public junior high schools in Metro City based on spatial data from 2025. School coordinate data was

obtained through location point measurements using *the Global Positioning System* (GPS) and mapping using ArcGIS 10.x software.

Distribution of Public Junior High Schools in Metro City

Metro City had 10 public junior high schools spread across five subdistricts, namely Metro Pusat (3 schools), Metro Timur (3 schools), Metro Utara (2 schools), Metro Barat (1 school), and Metro Selatan (1 school). Each subdistrict had at least one public junior high school, indicating a relatively even distribution. The schools were generally located in densely populated residential areas and close to secondary collector roads, which indicated easy access to education for the community. More detailed data on the distribution of junior high schools was provided in Table 1 and Figure 2.

Table 1. Coordinate Points of Public Junior High Schools in Metro City for the Year 2025

No	School	Coordinates	
		Latitude	Longitude
1	State Junior High School 1 Metro City	-5.12759	105.30709
2	Metro City Public Junior High School 2	-5.11993	105.33008
3	Metro City Public Junior High School 3	-5.11677	105.30768
4	Metro City Public Junior High School 4	-5.11819	105.32742
5	Metro City Public Junior High School 5	-5.15983	105.30583
6	State Junior High School 6 Metro City	-5.09722	105.28468
7	State Junior High School 7 Metro City	-5.14651	105.33258
8	Metro City Public Junior High School 8	-5.08672	105.34052
9	Metro City Public Junior High School 9	-5.15181	105.26909
10	Metro City Public Junior High School 10	-5.09049	105.32001

Source: Results of the 2025 Field Survey

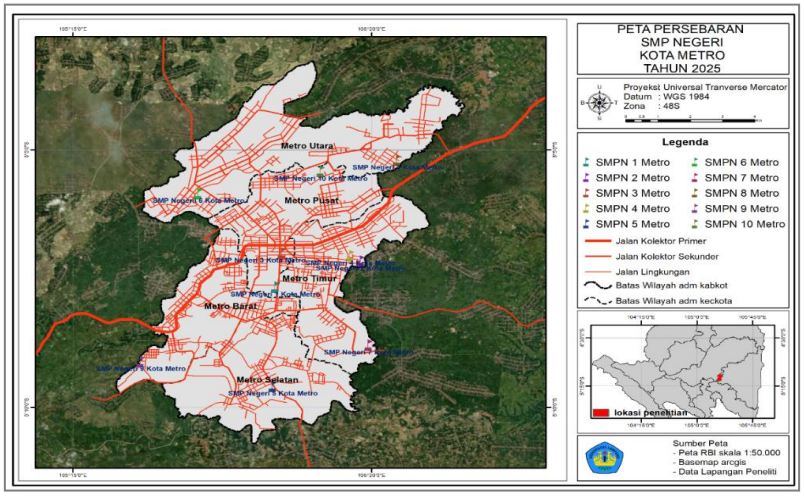

Figure 2. Map of the Distribution of Public Junior High Schools in Metro City in 2025

Table 1 and Figure 1 show the spatial distribution of public junior high schools throughout the administrative area of Metro City, which consists of five subdistricts. Based on the mapping results, Metro Pusat District has three schools, namely SMPN 1, SMPN 3, and SMPN 10, which are located in the city center and close to the government center. Metro Timur District also has three schools, namely SMPN 2, SMPN 4, and SMPN 7, which are spread across areas that are developing as new residential zones and educational areas. Furthermore, Metro Utara District has two schools, namely SMPN 6 and SMPN 8, while Metro Barat and Metro Selatan Districts each have one school, namely SMPN 9 and SMPN 5. This number and distribution show that the entire Metro City area has access to public junior high school facilities.

Spatially, the distribution of these schools shows a relatively even spread throughout the city. Although there is a higher concentration in two subdistricts, namely Metro Pusat and Metro Timur, the overall distribution still shows an even distribution of educational services between regions. This reflects that the school development policy in Metro City has taken into account the aspect of equitable access to education, so that no region is completely without public school facilities. This distribution is important in the context of *spatial equity*, as it allows every resident in each subdistrict to have the same opportunity to access junior high school education.

In addition, from the interpretation of the map in Figure 1, it can be seen that most of the school locations are close to the main road network, both secondary collector roads and neighborhood roads. This condition shows that accessibility is a dominant factor in determining school locations, where each location can be easily reached by the surrounding community. This pattern of proximity to road infrastructure reinforces the effectiveness of the spatial distribution of schools in fulfilling their public service function and demonstrates the integration between education planning and spatial planning in Metro City. Thus, the data in Table 1 and Figure 1 not only show physical distribution but also indicate the success of regional planning based on equitable access to education in urban areas.

Distribution Pattern of Public Junior High Schools (SMPN) in Metro City

The data obtained from the field survey on the coordinate locations of public junior high schools was then used to analyze the distribution pattern of public junior high schools in Metro City using *Average Nearest Neighbor* (ANN) in ArcGis. The data used to analyze the distribution pattern of public junior high schools in Metro City is the X and Y coordinate point data obtained from direct field observations using *a Garmin gpsmap 64s GPS* device. These points represent the absolute location of public junior high schools in Metro City on the earth's surface.

The coordinate point data will be entered into the administrative map of Metro City on *ArcGis software* so that the distribution pattern can be seen. After the locations of the public junior high schools were detected on the map, the next step was to perform a *nearest neighbor analysis* using *ArcToolbox Average Nearest Neighbor* in *ArcGIS software.* The

calculations performed using ANN in *ArcGIS software* will automatically generate distribution pattern calculations.

The coordinates of the location points obtained from the research were entered and processed using Geographic Information System (GIS) software, namely *ArcGIS*. This step aimed to obtain calculations of the distribution pattern of public junior high schools in Metro City. After all school location points were successfully entered into *ArcGIS*, the next step was to perform *a nearest neighbor analysis*. This analysis is performed using the *Average Nearest Neighbor* facility available in *ArcToolbox* in ArcGIS software. The data used in the analysis of the distribution pattern of public junior high schools in Metro City are X and Y coordinate points obtained through field observations using *Garmin GPSMAP 64s GPS* devices. These coordinate points represent the absolute positions of each public junior high school in Metro City on the earth's surface.

By applying this method, the software will automatically calculate and compare *the observed mean distance* between the nearest neighbors with the expected mean distance in a random distribution *pattern*. This comparison produces an index called *the Nearest Neighbor Index* (NNI).

- If the NNI value is < 1, then the distribution of points tends to *be clustered*.
- If the NNR value = 1, then the distribution of points is considered *random*.
- If the NNR value is > 1, then the distribution of points shows a tendency to be evenly *dispersed*.

In addition to producing index values, *Average Nearest Neighbor* is also equipped with a significance test (*z-score and p-value*) to determine whether the detected distribution pattern has statistical significance or is merely coincidental. The application of *Average Nearest Neighbor* in this study aims to identify the quantitative and measurable distribution patterns of public junior high schools in Metro City. The results of the *Nearest Neighbor* analysis for the distribution pattern of public junior high schools in Metro City are presented in Figure 2.

From Figure 2, we can see the results of calculations and data processing performed automatically by *the Average Nearest Neighbor Tool*, which produced an *observed mean distance* value of 2184.3331 meters, an *expected mean distance* value of 1213.1473 meters, with a *study area* of 58869058,091028. From this process, *a Nearest Neighbor Ratio* (T) of 1.8 was obtained. The distribution of public junior high schools in Metro City obtained a nearest neighbor index (index T) of 1.8 in accordance with *the Nearest Neighbor Index*, where if the index T has a value or magnitude > 1, it is found that the distribution pattern of public junior high schools in Metro City falls into the evenly distributed (*dispersed)* category.

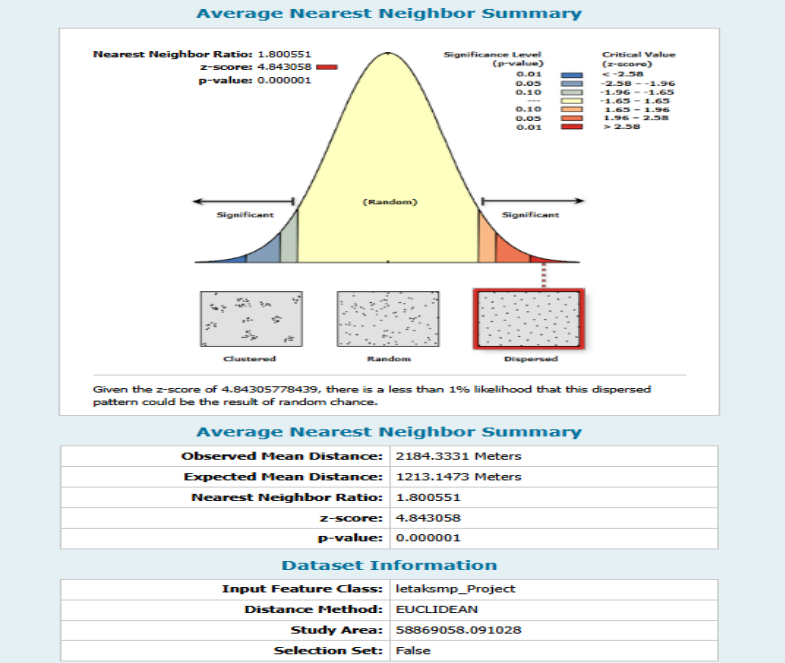

Figure 2. *Nearest* Neighbor Analysis Results.
Source: Research Data 2025.

When related to the distribution pattern theory according to Haggett & Chorley (1972), *the observed mean distance* is the average distance obtained from measurements between a point and its nearest neighbor (Ju). Meanwhile, the expected mean distance is the average distance calculated when all points are assumed to be randomly distributed (Jh). The nearest neighbor ratio (T) is an index that shows the degree of nearest neighbor distribution. To prove the index result of T=1.8, a manual calculation can be performed using the Nearest Neighbor Analysis method through the distribution pattern formula proposed by Haggett & Chorley (1972) as follows:

1. The nearest neighbour dispersion index (T) value is obtained through the formula $T = \frac{Ju}{Jh}$
2. The formula used to find the value of Jh is $Jh = ½\sqrt{p}$
3. The formula used to find the value of Ju is $Ju = \frac{\sum j}{\sum N}$

Based on the formula above, the following calculation results are obtained:

- $Jh = ½\sqrt{p}$ $Jh = \frac{1}{2\sqrt{0,00000016987}} = 1213.1421m$
- $Ju = \frac{\sum j}{\sum N} = \frac{21843,331}{10} = 2184.3331$
- $T = \frac{Ju}{Jh} = \frac{2184,3331}{1213,1421} = 1.80055$

From these calculations, we can compare the T results with the Distribution Pattern Categories according to Hagget & Chorley (1972) as follows:

1. *Clustered* Pattern if T < 1
2. *Random* Pattern if the T value = 1 or approaches 1
3. *Dispersed* pattern if the T value is > 1

Based on the calculation results and data processing of the nearest neighbor analysis of the distribution of public junior high schools in Metro City, the nearest neighbor distribution index (T Index) value obtained was 1.8, in accordance with the Hagget & Chorley (1972) distribution category. From the resulting mapping, the T Index value obtained formed a dispersed pattern following the road network.

The results of the study on *the distribution of public junior high schools in Metro City* show the importance of applying spatial analysis in the context of equal access to education in urban areas. This approach provides a comprehensive picture of how local government policies regulate the distribution of educational facilities so that they are accessible to all communities in a fair manner. The spatial analysis applied in this study, through mapping and *Nearest Neighbor Analysis (NNA)* calculations, was able to describe the relationship between the distribution pattern of schools, the physical conditions of the region, and the infrastructure network that affects educational accessibility in Metro City.

A total of ten public junior high schools are spread across five subdistricts in Metro City, with each subdistrict having at least one public school. This distribution shows equitable access to education between regions, indicating that education development policies in Metro City have considered spatial equity and public service efficiency. These results are in line with the findings of Huang, Cui, and Ma (2023) and Han (2021), which confirm that the equitable distribution of educational facilities in urban areas is a strategic step to reduce access gaps and increase inclusive learning opportunities for all city residents. The highest concentration of schools was found in Metro Pusat and Metro Timur subdistricts, each with three schools. Both areas are located near the center of government and densely populated residential areas, reflecting the high demand for education in areas with large population densities. This phenomenon is consistent with the results of research by Wang and Tang (2013) and Zhang et al. (2019), which explain that educational facilities in urban areas tend to be located near centers of population activity and major transportation networks to maximize accessibility and efficiency of educational services.

Most public junior high schools in Metro City are located around secondary collector roads and neighborhood roads, thus providing good accessibility for the community. The spatial relationship between school locations and road networks shows that transportation is one of the main considerations in planning educational facilities. This is in line with the findings of Buttenheim et al. (2012) and Vadrevu and Kanjilal (2016), who state that proximity to transportation infrastructure plays an important role in ensuring equitable public services, including education. This condition shows that the construction of schools in Metro City not only considers administrative distribution but also pays attention to the

ease of mobility for students and educators as a form of spatial efficiency in public services.

This relatively even distribution illustrates the principle of *spatial equity*, where every resident in each subdistrict has relatively equal opportunities to access public junior high school education. The principle of spatial equity emphasizes the importance of integrating education policy and spatial planning to ensure sustainable access equity (Taleai, Sliuzas, & Flacke, 2014; Du, Liu, & Luo, 2023). Thus, the results of this study confirm that Metro City has implemented an educational development approach that integrates geographical dimensions and public policy, creating an effective model of equity in the context of medium-sized cities in Indonesia.

The results of *the Nearest Neighbor Analysis (NNA)* show an index value of 1.8, which indicates a dispersed pattern of school distribution. This value shows that public junior high schools in Metro City are not concentrated in one particular area but are efficiently spread across various subdistricts. This distribution pattern supports the equitable distribution of educational services and avoids the accumulation of facilities in the city center. This finding is in line with the research by Du et al. (2023) and Han (2021), which shows that an even spatial distribution can strengthen equitable social development and improve the accessibility of public services.

The distribution pattern that has formed is also closely related to the physical and morphological conditions of Metro City, where school locations follow the direction of regional development and the main road network. This is in line with the findings of Yan-hua, Xu, and Wang (2017) and Kalir and Dillon (2019), who state that the physical characteristics of a region have a significant influence on the efficiency of public service distribution. Based on the theory of Haggett and Chorley (1972), a T index value > 1 indicates a dispersed pattern that reflects spatial efficiency because it avoids excessive concentration and maximizes service coverage. Thus, the results of this study not only confirm the validity of the NNA method in analyzing the distribution pattern of educational facilities, but also support the principle of spatial effectiveness in urban education planning (Perez et al., 2021; Ren, Tong, & Kwan, 2014).

In terms of policy, the results of this study have important implications for education planning and spatial planning in Metro City. The even distribution pattern shows that school development has taken into account the needs of the population and infrastructure conditions, but continuous evaluation of potentially growing suburban areas is still needed. Local governments can utilize the results of this spatial analysis as a basis for the Regional Spatial Plan (RTRW) and the Regional Medium-Term Development Plan (RPJMD) so that educational development policies remain in line with the direction of urban development (Kalir, 2018; Al-Rashid, 2020). The use of GIS (ArcGIS) technology and the NNA method has proven to be effective in evaluating the distribution of educational facilities, as emphasized by Shi (2024) and Yu et al. (2023), who state that data-based spatial analysis is an important instrument in realizing fair, efficient, and sustainable education policies.

Overall, this study shows that the distribution pattern of public junior high schools in Metro City reflects good spatial equity and synergy between education policy and spatial planning. The integration of a spatial analysis approach into education policy is highly recommended to ensure the sustainability of equitable access in the future. Thus, the results of this study are not only relevant to policy makers at the local level, but also contribute theoretically to the development of spatial justice-based educational geography studies in Indonesia.

Conclusion

The results of this study on the distribution of public junior high schools (SMPN) in Metro City show that the distribution of educational facilities in this region is relatively even and has taken into account the principle of spatial justice. There are ten public junior high schools spread across five subdistricts, with each subdistrict having at least one public school. This indicates that the education equity policy implemented by the local government is effective, especially in ensuring access to education for people throughout the city.

Based on the results of the nearest neighbor analysis using the Nearest Neighbor Analysis (NNA) method, a T index value of 1.8 was obtained, indicating a dispersed distribution pattern. This means that the location of schools is not concentrated in only one area, but is spread out along road networks and residential patterns. This distribution shows the integration of educational development and spatial planning policies that take into account accessibility and public service efficiency.

Overall, this study emphasizes the importance of applying GIS-based spatial analysis as a tool for evaluating the equitable distribution of educational facilities at the regional level. Integrating the results of spatial analysis into regional development planning—such as the Regional Spatial Plan (RTRW) and the Regional Medium-Term Development Plan (RPJMD)—can strengthen policies for equitable education. Thus, the provision of educational facilities in Metro City is not only oriented towards quantity, but also towards fair, efficient, and sustainable spatial distribution.

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