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Research article

Distribution Pattern of High School and Equivalent Education Facilities in North Penajam Paser Regency

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Abstract

Education in the current era is undergoing a significant transformation along with the rapid development of technology and information. In efforts to equalize education, it is clear that schools in urban areas generally have adequate facilities. Conversely, in rural or remote areas, many schools still operate with limited facilities. This study aims to analyze the distribution of educational facilities and the density of high school students in North Penajam Paser Regency. The method used is descriptive quantitative with the utilization of secondary data from BPS, the Ministry of Education and Culture, and the results of plotting location coordinates using Google Maps. Data were analyzed using Geographic Information Systems (GIS), as well as the Nearest Neighbor Analysis (ANN) and Hotspot (Kernel Density) methods. The distribution pattern tends to be clustered, as indicated by the results of the ANN (Average Nearest Neighbor) calculation of 0.628924 and a z-score value of -3.688721. This inequality is also reflected in the still-low residential density in several areas and the distribution of student numbers, with Penajam and Babulu districts having educational facility densities ranging from 0.052 to 0.055, with the highest student density reaching 748 to 1,128 students. This suggests that the level of educational facilities and the number of high school and vocational school students in North Penajam Paser Regency are not evenly distributed.

Keywords: Distribution of Educational Facilities, Senior High Schools, Vocational High Schools, Geographic Information Systems, North Penajam Paser, ANN, Hotspot

1. Introduction

Education in the current era has undergone significant transformation along with the rapid development of technology and information. Education is also a major pillar in the development of human resources and the progress of a nation. The goals of education can vary from improving skills and knowledge and preparing individuals for careers, to helping them develop the ability to think critically and independently (Syarief, 2018). In Indonesia, the compulsory education program has been updated from the previous 9 years, namely elementary school-junior high school, to 12 years, known as General Secondary Education (PMU). In Law Number 20 of 2003 Article 18 paragraph (3) also explains that the form of secondary education consists of Senior High School (SMA), Madrasah Aliyah (MA), Vocational High School (SMK), and Vocational Madrasah Aliyah (MAK), and other forms of schools of the same level.

Penajam Paser Utara Regency is a regency in East Kalimantan Province, Indonesia. This regency is located 177 km southwest of the capital of East Kalimantan Province, Samarinda. Penajam Paser Utara Regency is the result of the division of Paser Regency with an area of 3,333.06 km2 and a land area of 3,060.82 km2. Not only that, the population will continue to increase from year to year, this affects the population density which also increases. One factor in this increase in population is due to large urbanization following the designation of the Sepaku District as the location of Kota Nusantara, a new Indonesian city in East Kalimantan Province.

Building educational institutions is one of the social institutions that plays an important role in improving the quality of human resources for the survival of the nation. The regulation of the provision of school institutions takes into account the reach of the service area radius in relation to the basic needs of facilities that must be met in certain areas. (Mukhlis, M. & Musyawarah, R. 2019). One of the problems is the unequal distribution of educational facilities, especially schools, which are not evenly distributed between regions. Equity is specifically for secondary schools, because secondary school is the final education of the 12-year compulsory education program, this can be a benchmark for success for someone. In detail, the number of high schools, Islamic high schools and vocational high schools in Penajam Paser Utara Regency can be seen in table 1 below.

Table 1. Basic Education Data Source of the Ministry of Education and Culture, Penajam Paser Utara Regency, 2023

No	District	Number of Senior High Schools		Number of Vocational High Schools		Number of Islamic Senior High Schools	
		Public	Private	Public	Private	Public	Private
1	Babulu	1	0	1	1	1	2
2	Waru	1	0	1	0	0	0
3	Penajam	4	2	1	4	0	3
4	Sepaku	1	1	2	0	0	1
	Total	**7**	**3**	**5**	**5**	**1**	**6**

Based on table 2 above, it is known that the number of secondary schools in Penajam Paser Utara Regency is 27 schools consisting of 7 public senior high schools, 3 private senior high schools, 5 public vocational high schools, 5 private vocational high schools, 1 public Islamic high school and 6 private Islamic high schools. Based on the results of table 2 above, the sub-district with the largest number of secondary schools is in Penajam sub-district, where the sub-district is the center of government and access to facilities is fulfilled. Not only the number of schools, the number of students is also a factor that influences the quality of education in Penajam Paser Utara Regency. In detail, data regarding the number of high school students and equivalent in each sub-district in Penajam Paser Utara Regency in 2023 can be seen in Table 2 below.

Table 2. Basic Education Data Source of the Ministry of Education and Culture, Penajam Paser Utara Regency, 2023

No	District	Number of Senior High School, Vocational High School, Islamic Senior High School students
1	Babulu	1.095
2	Waru	745
3	Penajam	4.001
4	Sepaku	1.240
	Total	**7.081**

Based on Table 3 above, the number of students at the high school level in Penajam Paser Utara Regency is 7,081 with the largest number of students in Penajam District with 4,001 students and the lowest number of students in Waru District because in that district there is only 1 public high school and 1 private high school. The difference in a school area can affect the quality of a school, because schools in government areas are generally more in demand because they have more complete and adequate facilities, so they have the potential to produce intelligent students and skilled teachers. Not a few students in Penajam Paser Utara Regency choose to continue their studies in high school in Penajam District because public or private schools have more adequate school facilities and are close to the center of government.

In efforts to achieve educational equality, it is clear that schools in urban areas generally have very adequate facilities and infrastructure. Conversely, in rural or remote areas, many schools still operate with limited facilities, often even lacking teachers. Yet, the availability of facilities and infrastructure is a crucial component supporting the teaching and learning process in schools. Optimal management of these facilities has the potential to improve the quality of education. This inequality problem is not unique to rural areas; imbalances in the education system are also found in urban areas. The form of infrastructure is closely related to the growth and progress of a city (Utomo, D. S., & Amin, C. 2021).

The quality of education at the high school level in North Penajam Paser Regency is still relatively low, due to the lack of equal distribution of educational facilities in each sub-district and suboptimal educational infrastructure. Therefore, research is needed on spatial studies to determine the distribution patterns of educational facilities and the distribution of the number of high school students in North Penajam Paser Regency. Spatial patterns are the result of physical and social forms in the region. This spatial pattern is very important and is a very important topic in various aspects such as tropical ecology because of the high differences in tropical areas that give rise to low densities (Hidayah, B., & Amin, C. 2021). To analyze these distribution patterns, spatial analysis is needed. This study was conducted using a Geographic Information System (GIS), which has the ability to process data through a spatial approach related to environmental, economic, and other aspects, including distribution patterns. (Sible, M, et al. 2023). Geographic Information Systems (GIS) for mapping social issues are more developed at the national level,

with broader coverage compared to smaller ones (Sari, D. N, et al. 2023). This study aims to analyze the distribution of educational facilities and the density of high school students in North Penajam Paser Regency.

2. Research Methods

The method used in this study is a quantitative descriptive method by analyzing secondary data from related agencies. Classified as secondary information because this study utilizes information from related agencies, spatial information and attribute information. While the quantitative descriptive method is because in this study there are numerical elements from BPS information, and the results of this information will be presented through descriptive explanations. Spatial data in the form of an administrative map of North Penajam Paser Regency and the coordinates of the location of SMA, SMK and MA. The attribute data includes Dapodik (Basic Education Data) of the Ministry of Education and Culture and BPS (Central Statistics Agency). Dapodik (Basic Education Data) of the Ministry of Education and Culture plays a role in finding data on the number of high school level schools and the number of high school level students in North Penajam Paser Regency. Meanwhile, BPS (Central Statistics Agency) plays a role in finding information related to population data in North Penajam Paser Regency. On the Topographic Map (RBI), the sub-district shapefile and the shapefile of North Penajam Paser Regency are obtained from ina-geoportal, while the coordinates of high school level educational facilities are obtained from Google Maps. Data processing in this study uses Geographic Information Systems (GIS) and ArcGIS software. And this data processing uses 2 analyses, namely the nearest neighbor analysis or commonly called the Average Nearest Neighbor (ANN) used to determine the distribution pattern and coordinate points of high school level educational facilities and equivalent in North Penajam Paser Regency. Where with this process can produce clustered, random or uniform patterns. The final processing is the Hotspot method (Kernel Density) and quantitative descriptive supported by secondary data. Data analysis using statistical data obtained from institutions is then processed systematically and also uses the help of hotspot maps, and the results of the process are the number of high school students and equivalent in North Penajam Paser Regency

3. Results and Discussion

3.1 Distribution Pattern of High School and Equivalent Educational Facilities in North Penajam Paser Regency

Based on the Basic Education Data (Dapodik) of North Penajam Paser Regency in 2023, there are 27 high school level educational facilities, both public and private. To determine the distribution pattern of high school level educational facilities using GIS processing using the ANN (Average Nearest Neighbor) method. Research using the ANN (Averag e Nearest Neighbor) method has been widely carried out, such as in research (Valugunadi, A.N., et al., 2023) that this analysis produces a distribution map based on hotspot analysis and neighborhood analysis or ANN (Average Nearest Neighbor). In addition, this method is also used to determine distribution patterns, namely clustered patterns, random patterns, and uniform patterns (regular). Based on this, the results of the distribution map of high school level educational facilities in North Penajam Paser Regency can be seen in the following figure:

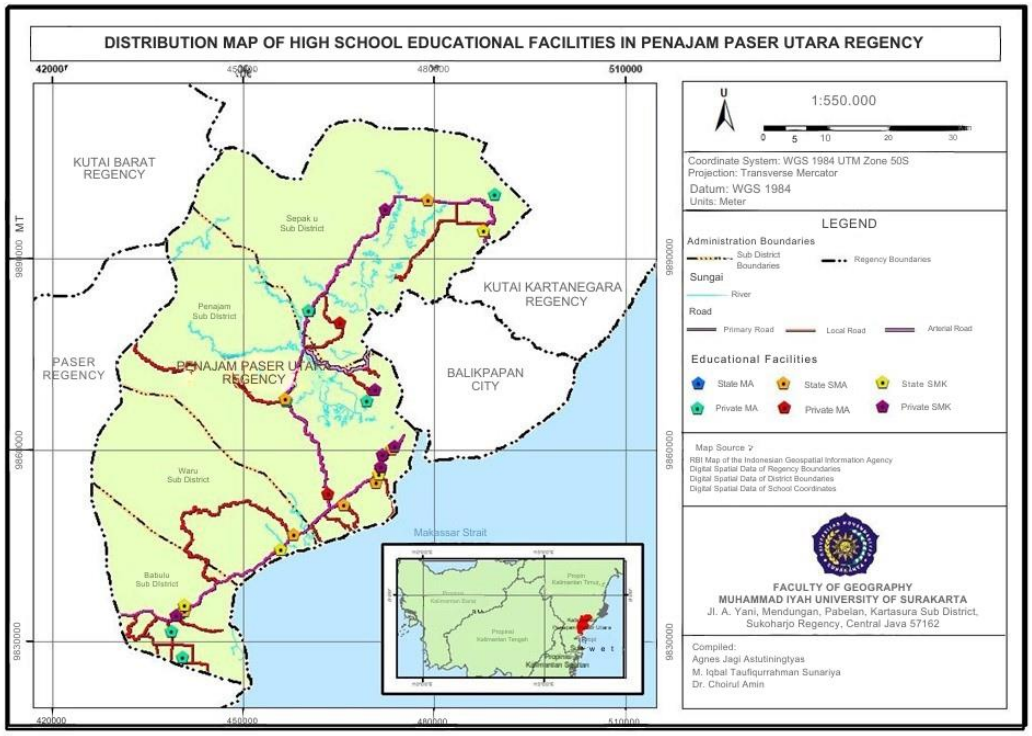

Figure 1. Map of Distribution of Educational Facilities in North Penajam Paser Regency

There is a distribution pattern of educational facilities in North Penajam Paser Regency which is processed from the location coordinates of all secondary schools using ANN (Average Nearest Neighbor) in Figure 2 below:

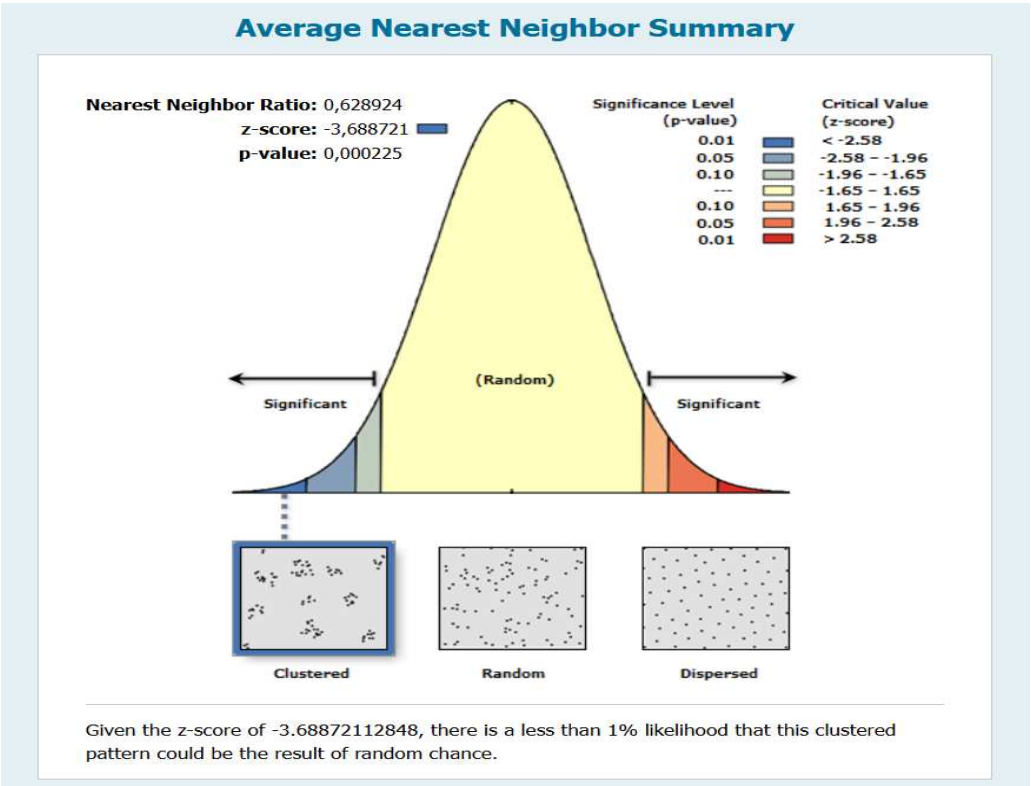

Figure 2. Distribution Pattern of Educational Facilities in North Penajam Paser Regency Using the ANN (Average Nearest Neighbor) Method

Based on the results of the data processing above, the coordinate data obtained from Google Maps, it can be seen that in Penajam Paser Utara Regency there are 27 points of high school level schools consisting of 7 public high schools, 3 private high schools, 5 public vocational schools, 5 private vocational schools, 1 public MA school and 6 private MA schools. If seen on the map of the distribution of high school level schools, of the 4 sub-districts in Penajam Paser Utara Regency

there is 1 sub-district that only has 1 public high school level school, namely Waru Sub-district, while Penajam Sub-district is the sub-district that has the most number of schools compared to the other 3 sub-districts because this sub-district is the center of government where access and facilities are very complete and easy to get.

Judging from the results of the distribution point map of high school level educational facilities and equivalents, it has not shown the correct distribution pattern, therefore further data processing was carried out using the ANN (Average Nearest Neighbor) method. This method is used to calculate random distances to the nearest neighbor using a random point pattern to obtain more accurate and easily analyzed results. The results of the distribution pattern of high school level educational facilities and equivalents in North Penajam Paser Regency can be seen in Figure 2 above. The results of data processing through ANN (Average Nearest Neighbor) show that the value of ANN (Average Nearest Neighbor) is 0.628924 where this value can be categorized as close to 0 (zero). The results obtained that the distribution pattern of high school level educational facilities shows a type of clustered distribution pattern, where the z-score value shows a value of -3.688721, from the results of the z-score value is at the value <-2,58 meaning that the results of the clustered pattern are accepted.

In the ANN (Average Nearest Neighbor) distribution pattern which obtained clustered results, it shows that the distribution of high school level educational facilities in North Penajam Paser Regency is still very uneven, the distribution of high schools in each sub-district is still clustered and there are still sub-districts that have a small number of educational facilities, these areas are usually far from the city center or government and remote areas such as areas that still have many forest areas. The clustered distribution pattern can be said that the development of high school level is still less regular and uneven. This is in accordance with the distribution map which clearly shows the Waru and Sepaku sub-districts which have few educational facilities and the Penajam and Babulu sub-districts which have many educational facilities.

The distribution of educational facilities in Penajam Paser Utara Regency still shows an imbalance between sub-districts. Some sub-districts are considered underdeveloped in terms of secondary school provision, as most of these schools are concentrated in urban or government areas, particularly in Penajam District. As the regency capital and administrative center, Penajam District has more comprehensive infrastructure and facilities, making it easier for the public to access secondary education. Furthermore, this sub-district also has potential for development in various sectors, one of which is education. This is why the number of high schools and equivalents in Penajam District is higher than in other sub-districts in Penajam Paser Utara Regency.

3.2. Residential Density and Number of High School Students and Their Equivalents in Relation to Educational Facilities in North Penajam Paser Regency

In addition to distribution patterns, the number of high school students also significantly influences equity, as good equity will impact educational quality. Therefore, a GIS-processed map of residential density in North Penajam Paser Regency is shown in Figure 3 below.

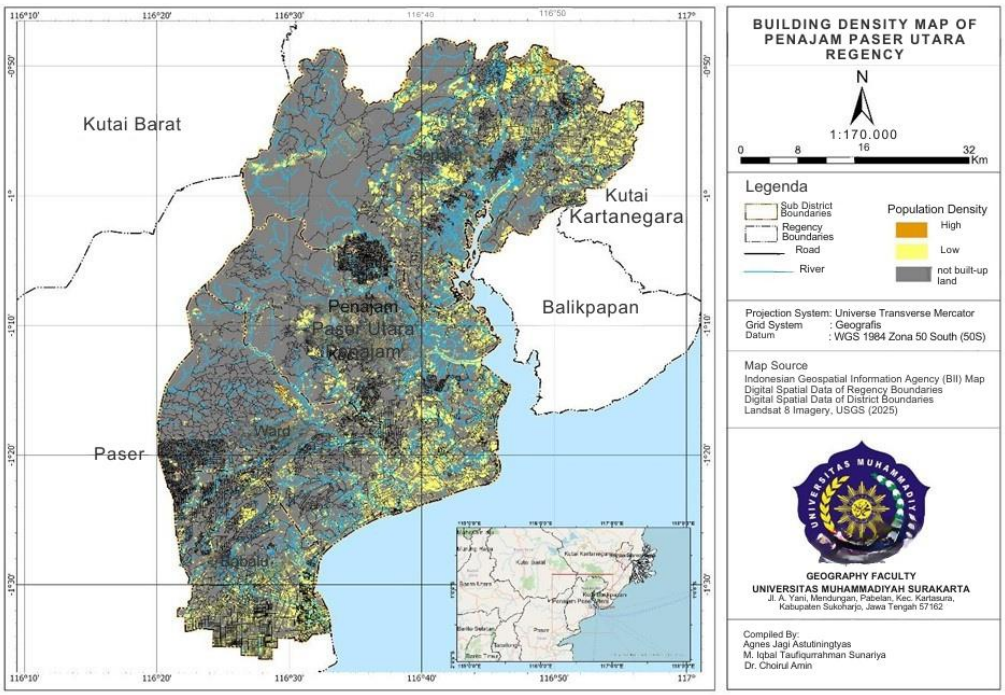

Figure 3. Settlement Density Map in North Penajam Paser Regency

In addition to presenting a map of residential density in Penajam Paser Utara Regency, this map also displays the distribution of high school students in the regency. This map was generated through data processing using Kernel Density in a Geographic Information System (GIS). The visualization, shown in Figure 4 below, shows the density of high school students at each school location in Penajam Paser Utara Regency.

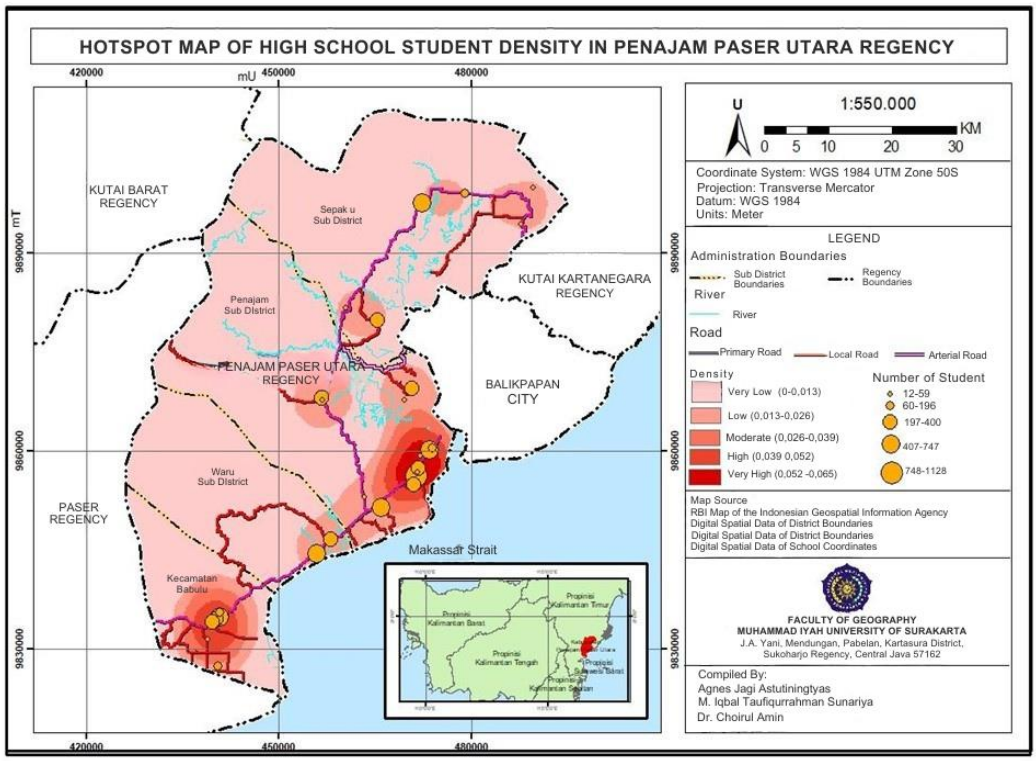

Figure 4. Map of Student Density Hotspots in North Penajam Paser Regency

Research on school density and the number of students at the high school level in North Penajam Paser Regency is very important to understand the level of equality of secondary education in each sub-district. This research on the density of educational facilities was conducted to determine the extent to which the community can access the nearest secondary school in their area. Through this research, it is hoped that students can more easily choose a secondary school that suits their

residential location. In addition, this research can also have an impact on the distribution or equality of the number of students in each sub-district. In Figure 3, it can be seen that North Penajam Paser Regency is still dominated by forests or it can be said that there is still very little built-up land in North Penajam Paser Regency. In Figure 3, settlements are dominated in Sepaku and Penajam Districts, although the density class is still low, this shows that settlement density also affects the distribution of educational facilities, where areas with high density are still not reached by educational facilities. Therefore, it is also necessary to study the number of students and the density of the number of students according to the distribution of educational facilities in North Penajam Paser Regency (Jubit, et al., 2025).

The analysis of student density using the Kernel Density process produces a hotspot map of educational facility density and high school student density in North Penajam Paser Regency. As in Figure 4 above, the results show that the sub-districts that have high school educational facilities are in Penajam and Babulu Districts with a density of 0.052-0.055. And the densest number of students is also in Penajam and Babulu Districts with a total of 748-1128 students. Therefore, it can be said that the distribution of educational facilities and the distribution of high school students in North Penajam Paser Regency is relatively uneven. The lack of educational facilities in Waru and Sepaku Districts also makes the number of students that can be accommodated in 1 school very limited, therefore many students choose to continue their secondary school in Penajam and Babulu Districts (Norita, et al., 2024).

Through the hotspot map of educational facility density as shown in Figure 4, the coverage of educational services in each region can be determined. For example, in Waru and Sepau Districts, there is still a lack of high school-level educational facilities or equivalent. Therefore, the closest alternative, namely continuing secondary education, is to go to Penajam District and Babulu District. In Babulu District, there is 1 public high school, 1 public vocational high school, 1 private vocational high school, 1 public Islamic high school and 1 private Islamic high school. Meanwhile, in Penajam District, there are 4 public high schools, 2 private high schools, 1 public vocational high school, 4 private vocational high schools and 3 private Islamic high schools. This condition allows students in Waru and Sepaku Districts to have secondary schools in the two districts. This coverage analysis is expected to achieve an even distribution of students and improve educational facilities throughout the Penajam Paser Utara district.

The disparity in high school and equivalent educational facilities in North Penajam Paser Regency is partly due to the lack of information received by the community regarding the location and condition of existing schools. Furthermore, other contributing factors include difficult access and limited supporting facilities, particularly in schools located in remote areas or near forest areas. Therefore, steps are needed to equalize educational facilities by improving the quality of high schools and equivalents to produce superior and competitive human resources. It is hoped that adding adequate facilities will also encourage people to attend schools in their local areas, so that they are not concentrated solely in cities. This effort is expected to have an impact on the more even distribution of students in each sub-district

4. Conclusion

Based on the research results, the distribution of high school level educational facilities and equivalent in North Penajam Paser Regency is still considered uneven. The distribution pattern tends to be clustered, as indicated by the results of the ANN (Average Nearest Neighbor) calculation of 0.628924 and a z-score value of -3.688721. This inequality is also reflected in the low residential density in several areas and the distribution of the number of students, where Penajam and Babulu Districts have educational facility densities with a density of 0.052-0.055 and there are the highest students reaching 748-1128 students. Many students choose to attend school in these areas because the available facilities are more complete, and supported by skilled teaching staff. Seeing this condition, the North Penajam Paser Regency government, especially the Education Office, is expected to pay more attention to the distribution of high school level educational facilities and equivalent as part of the 12-year compulsory education program. Facility improvements should not only be focused on urban areas, but also need to be expanded to rural areas, including those near forested areas. Efforts should include infrastructure improvements, such as road access to schools, the addition of qualified teachers, and the provision of adequate educational facilities. Furthermore, an evaluation of the secondary school zoning system is needed to ensure a more equitable distribution of students throughout North Penajam Paser Regency.

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Author Contributions

Conceptualization: Agnes Jagi Astuningtyas, Rikuto Daikai; **methodology**: Agnes Jagi Astuningtyas, M Iqbal Taufiqurrohman, Choirul Amin; **investigation**: Agnes Jagi Astuningtyas; **writing—original draft preparation**: Agnes Jagi Astuningtyas, Rikuto Daikai; **writing—review and editing**: Agnes Jagi Astuningtyas, M Iqbal Taufiqurrohman, Choirul Amin; **visualization**: Agnes Jagi Astuningtyas. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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