



Analysis of the Optimal Location for the Development of Senior High School Facilities in Response to the Zoning System in Siak Hulu District Using Geographic Information Systems

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Abstract. The presence of the zoning system in the education system in Indonesia as a provision for determining the location of new students affects the mobility patterns of school-age children in Siak Hulu District. The level of education is one of the indicators in measuring the Human Development Index in an area. However, the level of education must be balanced with the number of educational facilities that accommodate efforts to improve human quality. This sub-district, which has 12 villages with a total area of 98,707 hectares, has only 3 high school facilities, while when reviewed in SNI No. 3/1733/2004 the service coverage of high schools is only 3000 square meters with a population of 4,800 people. In addition, the zoning system that has been regulated does not include 3 villages in the zoning of Senior High School facilities in Siak Hulu District. This research seeks to provide recommendations for unserved areas linked to the zoning regulations in Siak Hulu Sub-district. The method used in this analysis is spatial data analysis with the weighting method and compared through weighted overlay. The results of the analysis show that there are three villages that are optimal locations for the construction of new high schools, namely Kepau Jaya Village, Tanjung Balam Village and Pangkalan Serik Village.

Keywords: Service Range, Zonation System, Education Facilities, GIS.

1. Introduction

Fulfillment of public services for basic facilities is the main role of the government as the manager of the public sector [1]. Public services consist of various efforts to fulfill goods and services that are generally basic needs in the form of health services, social services, employment services and education services [2]. Therefore, the existence of facilities in efforts to fulfill public services is a crucial issue. Referring to Indonesian National Standard (SNI) No.3/1733/2004, educational facilities are one of the facilities that must exist in an area in an effort to improve human resources. The educational facilities contain at least basic, secondary and higher education facilities [3]. The existence of educational facilities is in line with efforts to improve the quality of human resources in the field of science [4]. Thus, the fulfillment of public services in the education sector is one of the efforts that can be used to encourage the quality of human resources in a region.

Improving the quality of human resources is a major challenge in national development. Education is a form of long-term investment because it is one of the determinants that affect the quality of human resources [5]. Therefore, human development must go hand in hand with the management of educational facilities in a region [4]. The provision of high school education facilities must be planned seriously because at this level a concentration of learning has been carried out so that students can develop knowledge according to their field of interest

High school education facilities in Siak Hulu sub-district have an important urgency in efforts to improve the quality of the population. The number of public high schools in Siak Hulu district is only three units namely SMAN 1 Siak Hulu, SMAN 2 Siak Hulu and

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SMAN 3 Siak Hulu. This condition is quite inversely proportional to the provisions of Indonesian housing and settlement standards which state that high school facilities are placed in residential areas with a population of 4,800 people and a coverage area of 3000 square meters while the current condition only has 3 public high schools for an area of 98,707 hectares of area and 110,327 people of population.

One of the challenges in providing education facilities is the zoning policy stipulated in Indonesian Minister of Education Regulation No. 14/2018. The zoning system is a system of dividing school applicant zones to enter one of the educational facilities in Indonesia. This zoning system aims to equalize the level of education of the population so that there are no more high schools that can attract only superior students because for now the student selection model can only be done in certain neighborhoods [6]. In addition, the zoning PPDB aims to guarantee new students objectively, accountably, transparently and without discrimination to improve access to education services [7]. However, the zoning system has limitations concerning geographical aspects and efforts to increase students' interest in learning through appreciation. First, zoning regulations based on the nearest location of prospective students cause students' academic achievements in previous education to be undervalued because they cannot compete in schools that have better quality [8]. Second, if the number of educational facilities is not able to accommodate the number of residents if it is located in a dense residential center area, which causes a buildup of prospective student registrants in dense areas and vice versa in less populated areas.

Basically, residents will choose the closest area that can be reached to reach a facility or special need [9]. Therefore, a facility must have a reach threshold called service reach. Service reach is the relationship between the center of service facilities and the desire of the community to go to the service center. Not only that, service coverage is also related to access and distance and the ease of reaching a service center [10]. The existence of a zoning system is very similar to the application of Christaller's central place theory. However, the unpreparedness of an area can actually make this theory inapplicable as well as inequality of facility services.

The education zoning system, as stipulated in Indonesian Minister of Education Regulation No. 17/2017, requires each school to accept at least 90% of students who live in the closest radius to the education facility as evidenced by a family card or domicile certificate. In the zoning system, there are some shortcomings if it is connected to the science of planning. One of these problems is that there are still disparities in the development of educational facilities throughout Indonesia so that areas that lack educational facilities will be a little difficult and have a long radius in accessing educational services, besides that, there will be a possibility that unreached service areas will experience loss of service where residents will choose other service places outside the main sub-district. This condition will certainly affect the socioeconomic improvement of an area and show that an area has not been able to serve its community in matters of education.

2. Method

The method used in this analysis is spatial data analysis by utilizing spatial data in the form of maps and images and the information contained therein and analyzed through several techniques, namely buffer techniques through the formation of zones that lead outside the mapping object to see the distance of service coverage of facilities [11], scoring to determine development priorities in Siak Hulu District and finally analyzed using the weighted overlay method to form a recommendation map through an overlay

system between each variable used. Overlay is an important element in geographic information systems. This method seeks to provide an understanding of an area through various variables that are put together and produce analysis results from these variables. The overlay method seeks to unite elements or elements of separate regional elements into a more complex and integrated arrangement of regional elements between one element and another [12]. Overlay methods that are often used are clip, union, and intersect. In a spatial analysis, there is also an overlay method called weighted overlay. In the weighted overlay method, weights are allocated based on the relationship between factors that have been given weights [13] so that the comparison of each factor results in land use recommendations [14]. This method seeks to provide the results of an analysis of an area through the weighting of each variable so as to produce a result from the calculation of weighting and scores carried out.

3. Result and Discussion

The development of educational facilities must be in accordance with the provisions of location determination. There are three factors in determining the location of activities, namely the range of facilities, threshold limits, and central places [15]. The determination of the location of school building construction should at least consider land use factors, accessibility, service coverage and population distribution patterns [16]. Based on these provisions, the formulation of the location of high school education facilities to respond to the zoning regulations of Indonesian Education Ministry No. 17/2017 must at least consider land use factors, population density and distribution, service coverage of available high school facilities and accessibility of high school services and the coverage area of zoning regulations set by the Ministry of Education and Culture of the Republic of Indonesia.

3.1 Landuse of Siak Hulu District

The formation of land use data for Siak Hulu District was formulated using a supervised classification method using satellite imagery. Guided classification is a classification technique using training sample data as a means used to estimate the average value of variance and probability of each land cover [17], [18]. Guided classification is the process of segmenting objects in remote sensing images through training samples as pixel value estimates and processed through a statistical properties approach to form image value classes. In guided classification, the sample plays an important role because it shows the standard value in a particular class to form a land class.

Figure 1 shows the image map used in formulating the land use of Siak Hulu District through guided classification analysis. This classification produces three dominant classes found in Siak Hulu District. The three classes consist of land use as residential areas, agriculture and plantations and forests. Based on **Figure 2**, the land use of Siak Hulu District is still dominated by non-built land. Almost all settlements in Siak Hulu sub-district grow sectorally following the road network. To the north, the density of settlements is influenced by the urban development of the capital of Riau province, Pekanbaru City, because it is directly adjacent.

Table 1 shows the further analysis and weighting of each land use category. Based on **Table 1**, score 1 is given to areas that are not prioritized for new high school development, such as forest areas. Furthermore, score 2 is given to plantation areas because they are areas that can be converted for development needs and score 3 is given to residential areas because settlements are densely populated areas and are a priority for high school facility services.

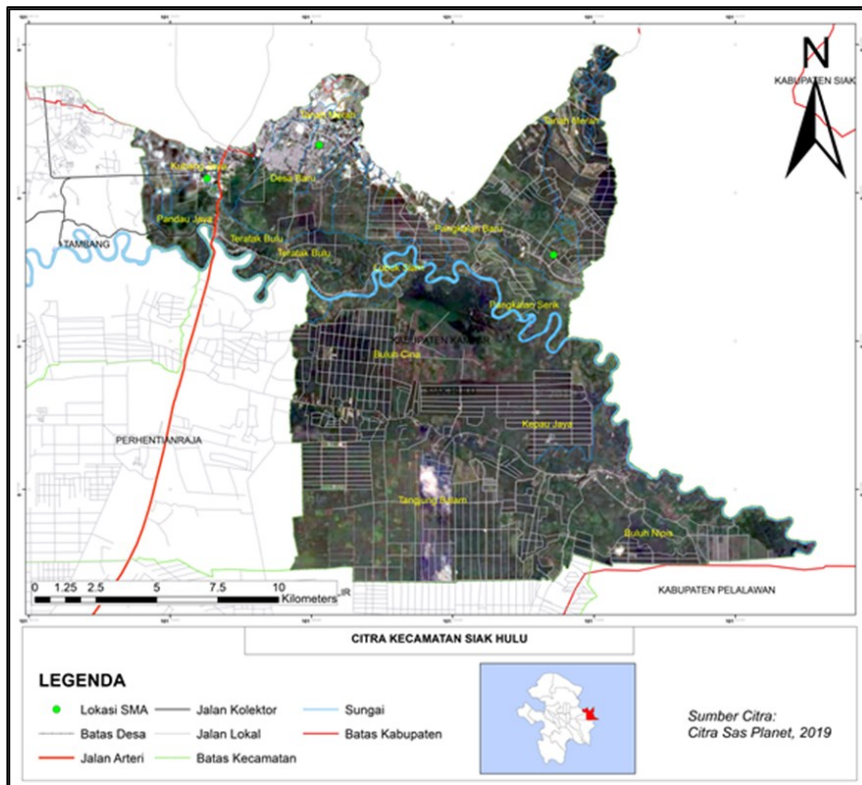


Figure 1. Satellite Imagery of Siak Hulu District

Table 1. Land Use Score Criteria
Source: Indonesian National Standard

Land Use	Category	Justification	Score
Residential	Recommended	Based on SNI No. 3/1733/2004 Education areas or education locations must be located in residential areas with a minimum population of 4,800 people and a service coverage radius of 3000 m	3
Agriculture	Moderate	Plantations can be converted to built-up area	2
Forest	Not recommended	forests are protected areas and cannot be converted easily.	1

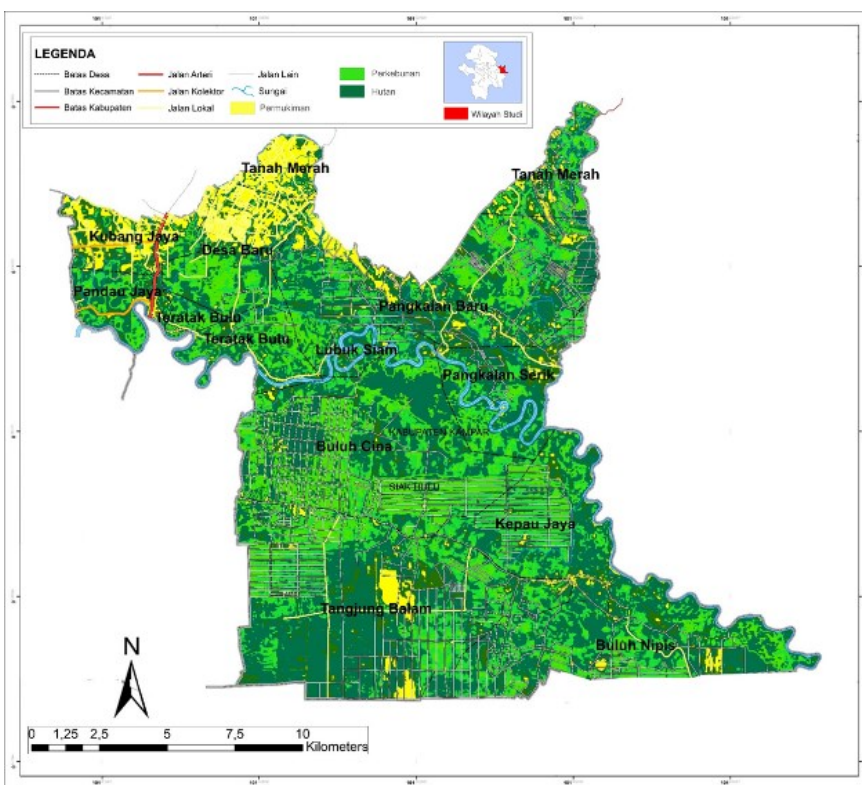


Figure 2. Land Use Map of Siak Hulu District

3.2 Population Density of Siak Hulu District

The total population of Siak Hulu District is 110,327 people divided into 12 villages. The highest population is in Pandau Jaya village of 32,354 people followed by Kubang Raya village with a population of 26,406 people and the lowest population is located in Tanjung Balam village of 960 people.

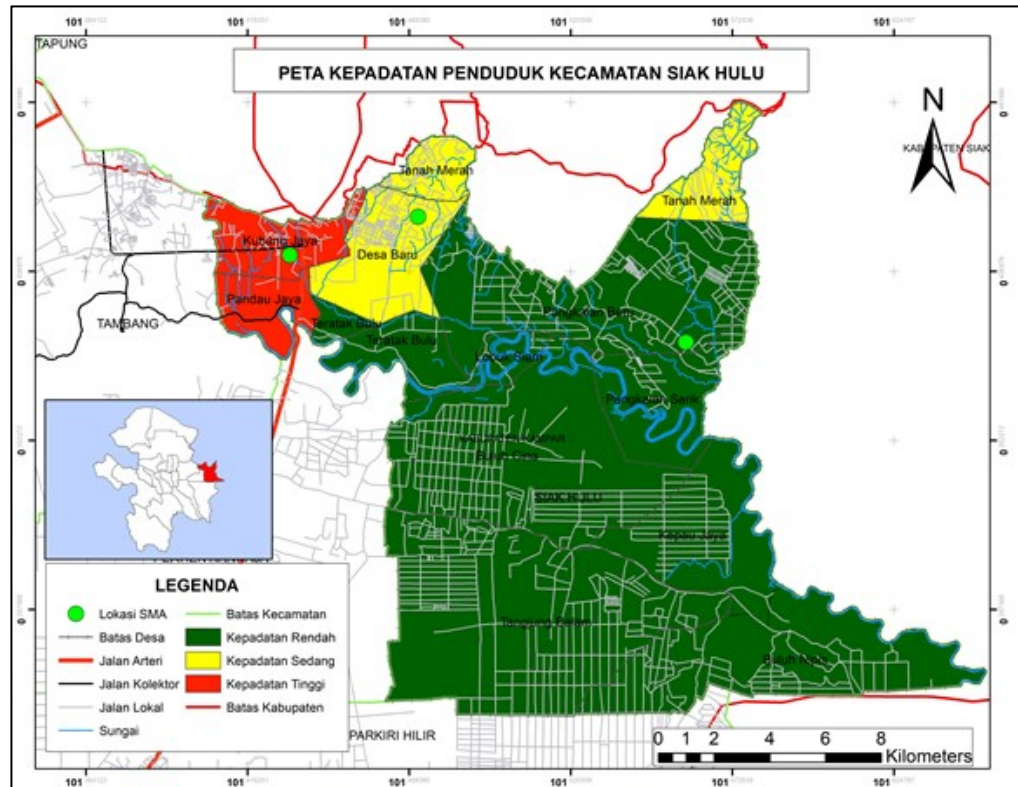


Figure 3. Population Density Map of Siak Hulu District

Figure 3 shows that the highest population density is located in the northern part of Pandau Jaya and Kubang Jaya villages. This is followed by Tanah Merah village and Desa Baru village. Population density in the north is again influenced by the development of Pekanbaru city. The next method is to give weight to the population density class. The determination of the population density class is formulated through the frequency distribution method, namely the largest population area divided by the smallest population divided by the number of classes so that the class interval is obtained as follows.

Table 2. Population Density Score Criteria

Population Interval	Density Class	Score
960 – 11.424	Low	1
11.425 – 21.890	Medium	2
> 21.890	High	3

The formulation of the frequency distribution classification to determine population density is done because school is an individual need that must be served for each child so that the planning needs to consider the population. A score of 3 was given to the high density population because the village is a priority for the development of a new high school to optimize high education services. Medium density areas are given a score of 2 and low density areas are given a score of 1 because they are not a priority for development due to their small population. In addition, the population for high school services has been clarified in Indonesian National Standard No. 3/1733/2004 where high schools in residential areas are held if the population reaches at least 4,800 people with a radius of 3000 square meters.

3.3 Zoning Area For New Student Admissions (PPDB) in Siak Hulu District

Based on the Riau Province PPDB website, the school zoning conditions for the implementation of new student admissions are described in **Figure 4**.

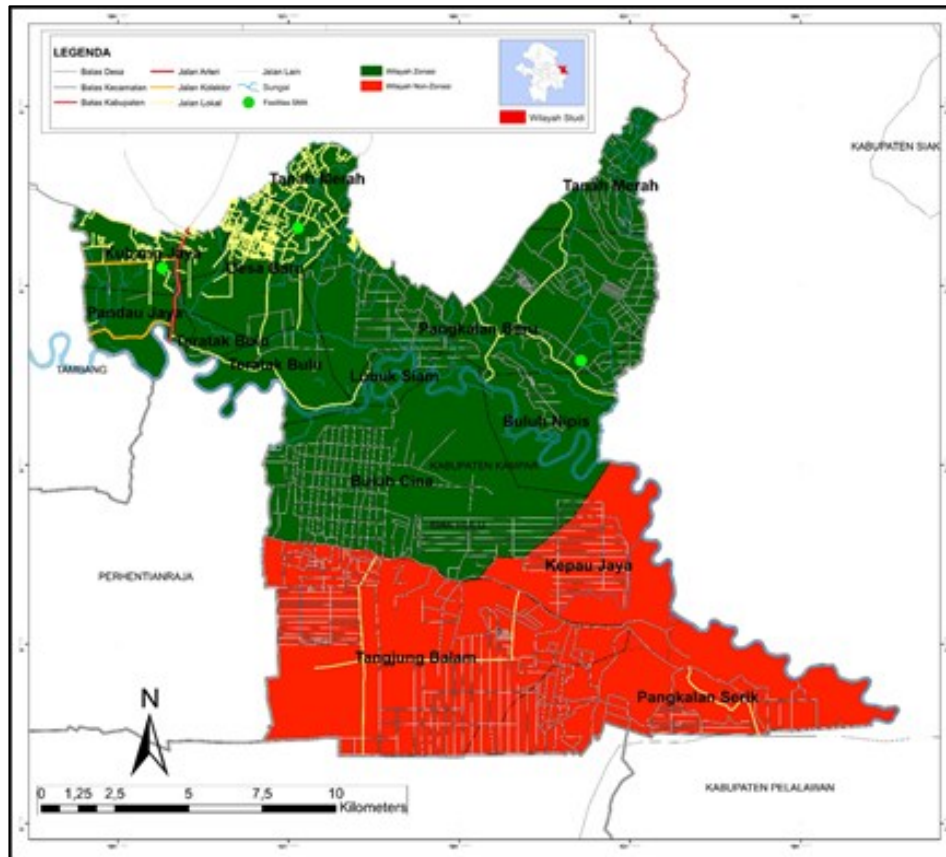


Figure 4. Zoning Map of New Student Admission (PPDB) for Senior High School in Siak Hulu District

Figure 4 explains the high school PPDB zoning areas in Siak Hulu sub-district according to the Siak Hulu Sub-district PPDB 2019/2020 source. The zoning area for State Senior High School 1 Siak Hulu includes Pangkalan Baru village, Baru village, Buluh Cina village, Buluh Nipis village. For the zoning area of State Senior High School 2 Siak Hulu consists of Teratak Buluh village, Kubang Jaya village, Lubuk Siam village. The zoning area for State Senior High School 3 Siak Hulu consists of Pandau Jaya village and Tanah Merah village. Meanwhile, Pangkalan Serik, Kepau Jaya and Tanjung Balam villages do not have high school facilities as PPDB zoning service locations in Siak Hulu sub-district.

Table 3. High School PPDB Zoning Score Criteria Source: Indonesian PPDB Zoning System

Village	PPDB Zone	Category	Score
Buluh Nipis	SMAN 1 Siak Hulu	Not Recommended	1
Pangkalan baru	SMAN 1 Siak Hulu	Not Recommended	1
Buluh Cina	SMAN 1 Siak Hulu	Not Recommended	1
Lubuk Siam	SMAN 2 Siak Hulu	Not Recommended	1
Teratak Buluh	SMAN 2 Siak Hulu	Not Recommended	1
Desa Baru	SMAN 1 Siak Hulu	Not Recommended	1
Tanah Merah	SMAN 3 Siak Hulu	Not Recommended	1
Pandau Jaya	SMAN 3 Siak Hulu	Not Recommended	1
Pangkalan Serik	None	Recommended	3
Kepau Jaya	None	Recommended	3
Tanjung Balam	None	Recommended	3
Kubang Jaya	SMAN 2 Siak Hulu	Not Recommended	1

Table 3 is the weighting of the zoning of high school facilities within the scope of Siak Hulu District. For unserved areas, a score of 3 is given because unserved areas are the main priority for high school development in Siak Hulu, while for areas that are already served, a score of 1 is given.

3.4 Service Area of Senior High School Facilities in Siak Hulu District

The standard for determining affordable facilities is based on the provisions in Indonesian National Standart No.3/1733/2004. Based on these provisions, the service area of senior high schools in residential areas is 3000 square meters. For the next service coverage category, a service size of 4500 square meters is determined as the moderately affordable class and a coverage of >4500 square meters as the unaffordable category. with the moderately affordable category and above 4500 m for the unaffordable category. The method used in determining the service coverage of senior high schools is the multiple ring buffer method which seeks to describe the service coverage area of a facility.

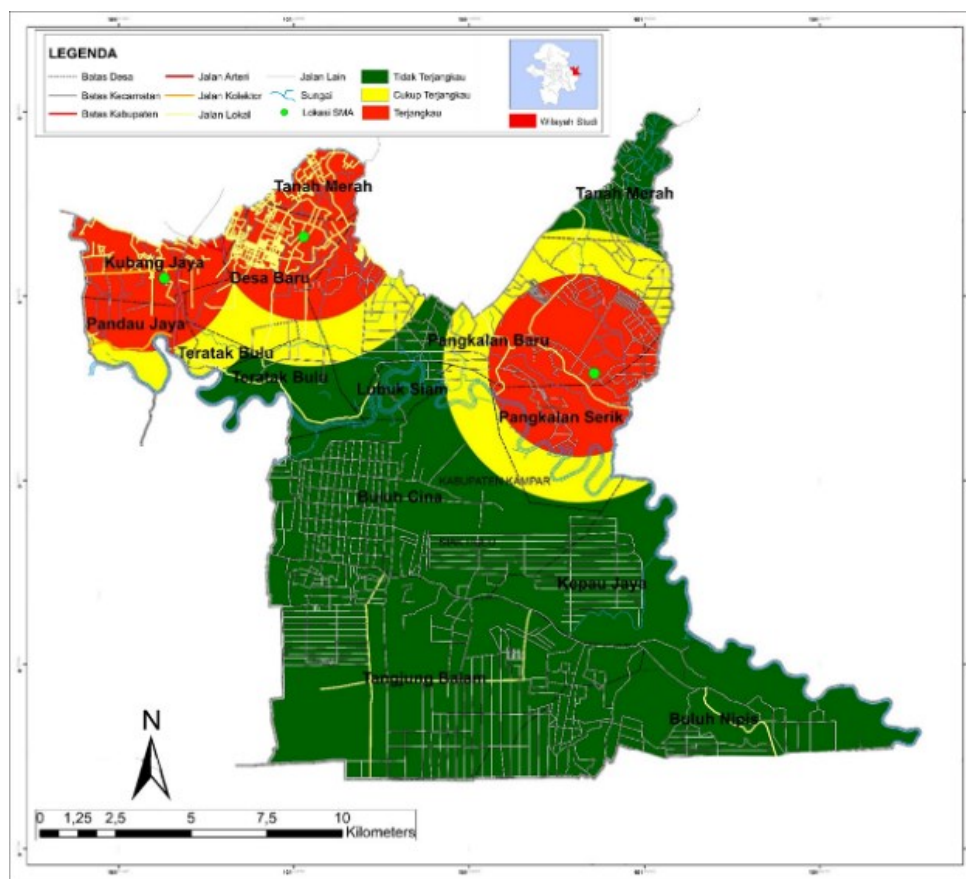


Figure 5. Map of High School Service Area of Siak Hulu District

Figure 5 describes the areas served by senior high school education facilities in Siak Hulu sub-district. Based on this figure, the most dominant category is the unreachable category. This means that the area of Siak Hulu sub-district is inversely proportional to the number of high school education facilities available.

Table 4. Senior High School Service Area Score Criteria
Source: SNI No. 03/1733/2004

Service Range (m)	Category	Justification	Score
3000	Affordable	Based on Indonesian National Standard (SN) No 03/1733/2004	1
3001-4500	Moderate		2
>4500	Not –Affordable		3

Furthermore, the service coverage map is also given a weight or score. **Table 4** shows the determination of the weight of each category, namely score 1 is given to areas that are already covered and are considered not a priority for the construction of new

high school facilities, in **Figure 5**, interpreted by red color. For score 2 is given to areas with sufficient service coverage, which is interpreted by yellow on the map and score 3 is given to areas with minimal or unreachable service coverage with the justification that this area is a priority for the development of high school education facilities.

3.5 Accessibility to High School Facilities in Siak Hulu District

Accessibility is a condition of ease of movement from one place to another that is closely related to distance [19], [20]. Accessibility analysis in this section is carried out by the buffer method by forming 3 classes, namely high accessibility and low accessibility. This accessibility analysis uses 3 types of road hierarchy, namely arterial, collector and local roads in determining the accessibility category. Areas adjacent to the 3 roads are assumed to have high accessibility, while areas far from the 3 roads above have low accessibility because the size of roads that are lower than local roads tend to be unsuitable for service facilities with high population mobility characteristics.

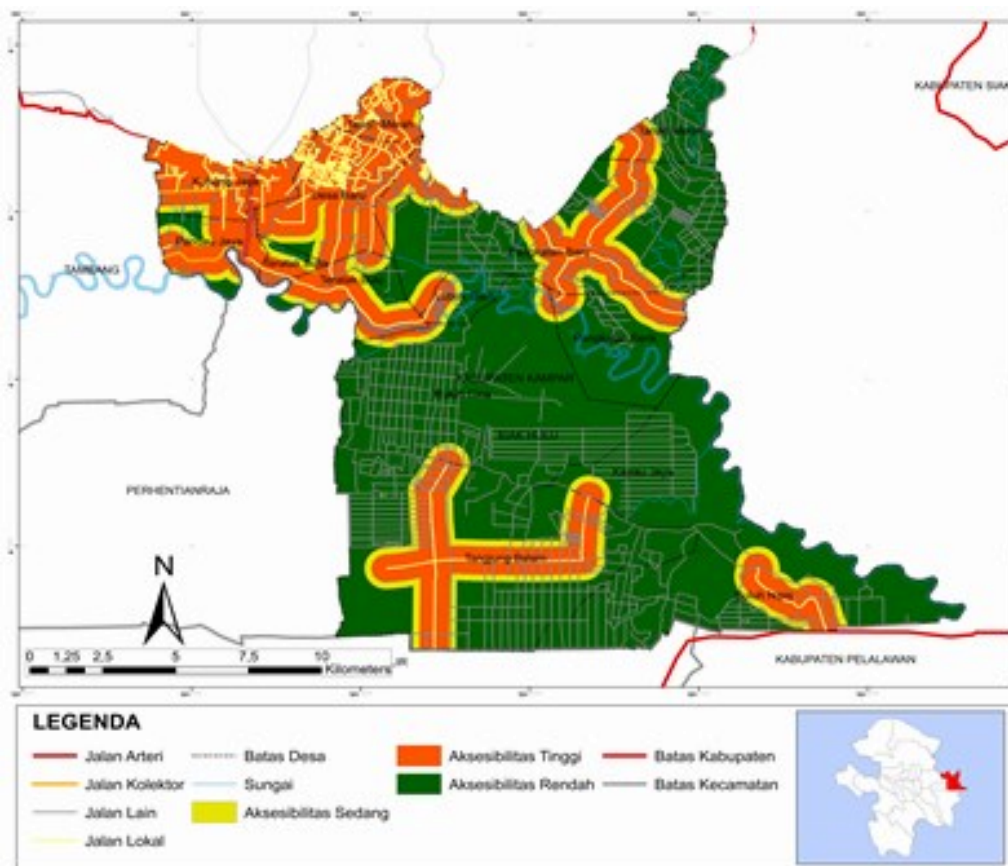


Figure 6. Accessibility Map in Siak Hulu District

Figure 6 shows that the dominance of accessibility to high school facilities in Siak Hulu District is still in the low category because the Siak Hulu area is still dominated by non-built land which has implications for the amount of road infrastructure. Based on **Figure 6**, it can be interpreted that orange areas are areas with high access, yellow areas have medium access and green areas have low access which is dominated by non-developed land and environmental road networks or other roads.

Table 5. Class Criteria Accessibility to High School Facilities

Distance from Main Road (m)	Category	Score
1000	Low	1
2000	Medium	2
> 2000	High	3

Furthermore, the map areas that have been interpreted are given a weight to each category described in **Table 5**. A score of 1 is given to areas that are not prioritized for new high school development, namely areas with low accessibility. For medium accessibility, a score of 2 is awarded and for high accessibility, a score of 3 is awarded, assuming that areas with high accessibility can facilitate student mobilization and are suitable for the placement of new high school facilities because they are more accessible.

3.6 Optimal Location for New High School Development in Siak Hulu District

Recommendations for the construction of new high school facilities in Siak Hulu District are the result of a comparison of all the analysis that has been done.

Table 6. Comparative variables of weighted overlay analysis

Variable	Classification	Category	Score
Land Use	Residential	Recommended	3
	Pantation	Moderate	2
	Forest	Not Recommended	1
Population Density	High Density	Recommended	3
	Medium Density	Moderate	2
	Low Density	Not Recommended	1
PPDB Zoning Area	Non-Zoning Area	Recommended	3
	Zoning Are	Not Recommended	1
Facility Service Range	Not-Affordable	Recommended	3
	Moderate	Moderate	2
	Affordable	Not Recommended	1
Accessibility	High	Recommended	3
	Medium	Moderate	2
	Low	Not Recommended	1

There are five variables used, namely land use, population distribution, zoning area coverage, accessibility and service coverage of available high school facilities which are further described in **Table 6**. All available variables are analyzed using the weighted overlay method to produce a development recommendation.

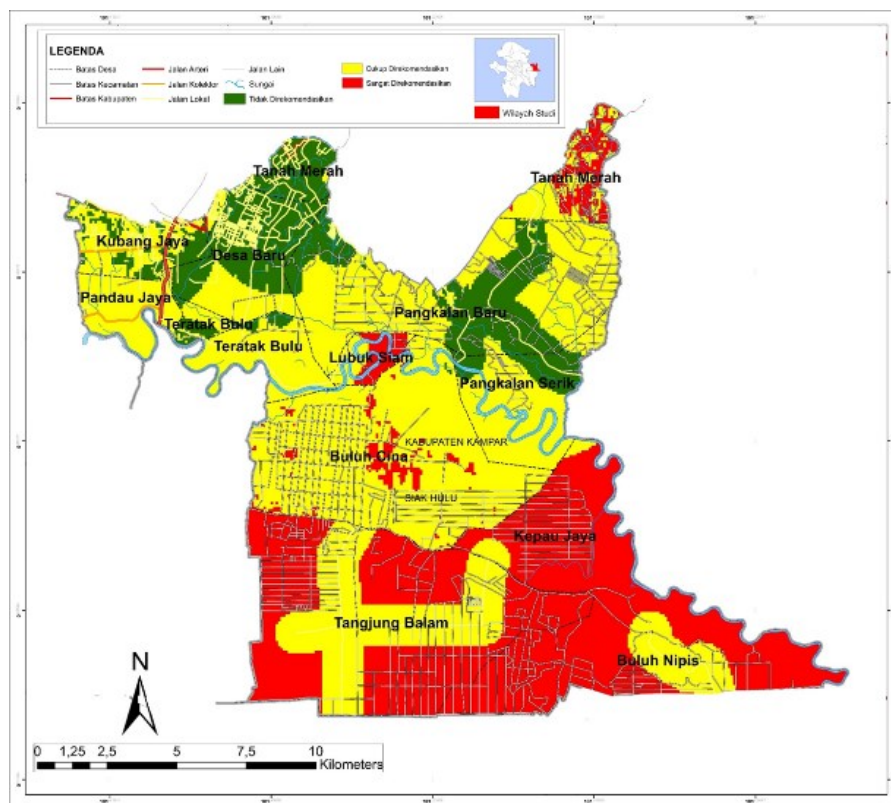


Figure 7. Map of Optimal Locations for New High School Development in Siak Hulu District

All weighting is done evenly until the total weight becomes 100%. The weighting given is 30% for the reach of high school facilities, with the justification that the reach of existing high school facilities is the most important consideration because areas that are not reached are areas that are prioritized. A further 15% weight is given to the zoning map, and 15% to accessibility. Furthermore, 20% weight is also given to the population density map and 20% to the land use map so that the analysis results are obtained as shown in **Figure 7**. **Figure 7** is a map of optimal locations for new high school development in Siak Hulu district, based on this figure, the southernmost area consisting of Kapau Jaya Village, Tanjung Balam Village and Pangkalan Serik Village is an area that is highly recommended for the construction of new high schools in terms of affordability and zoning. The yellow image is a fairly recommended image because it has sufficient affordability and the green color is for areas that are not recommended because high school facilities in the area are already very affordable.

4. Conclusion

Based on the analysis above, it can be stated that not all areas in Siak Hulu Sub-district are served by senior high school facilities both in terms of affordability and zoning. For affordability, southern areas such as Kapau Jaya, Tanjung Balam and Pangkalan Serik Villages are unreachable areas. In terms of zoning, these three villages are also not included in any of the high school service zones in Siak Hulu sub-district, so for the high school age population in these villages it will be very difficult to reach the high school facilities. In the end, it can be recommended for the construction of a new school in the southern area of Siak Hulu sub-district.

Based on the above analysis, there is an evaluation of the zoning system for high school education in Siak Hulu sub-district. The function of zoning regulations in senior high schools is actually a good idea to equalize education so that schools do not only tend to potential students from various regions. However, the shortcomings of this zoning system will be very risky if it is applied to areas that have not evenly distributed high school education facilities such as Siak Hulu sub-district. As a result, it creates areas that are not reached by educational facilities and the range of services is far and not in accordance with standards.

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6. Author's Declaration

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