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Selection of The Cirebon-Semarang High-Speed Railway Phase I (Cirebon-Brebes) Using ArcGIS 10.8

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Abstract

The high-speed railway line has great potential to increase economic growth in the area through which it passes, especially the area that is a transit point or stop of the train. In accordance with the National Railway Master Plan (RIPNAS), the development of high-speed railways in Indonesia will continue in the city of Surabaya. This research aims to plan the Cirebon-Semarang Phase I (Cirebon-Semarang) high-speed railway with reference to the starting point of research from previous studies. The data needed are land use, disaster, and topography data as secondary data that are processed using ArcGIS 10.8. This research includes the selection of the best traces using simple multi-criteria analysis. The alternative selected as the best route from the results of a simple multi-criteria analysis is alternative 2, with a route length of 43.2 km.

Keywords: ArcGIS 10.8, Railway Track, Simple Multi-Criteria Analysis, Disaster, Land Use

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1. Introduction

The Jakarta Bandung High-Speed Train (KCJB), which is now often called "WHOOSH," is a significant advancement for the development of long-distance trains in Indonesia with a maximum speed of up to 350 km/hour, which initially used conventional trains that only reached a maximum speed of 120 km/hour. In October 2023, KCJB officially operated to serve the public with a route from Jakarta (Halim Station)-Bandung (Tegalluar Station), covering a distance of 142.3 km which can be reached in 36 to 44 minutes and has 4 stations, namely Halim Station, Karawang Station, Padalarang Station, and Tegalluar Station. To support KCJB stops, connecting trains are provided at two stations, namely Halim Station integrated with Jabodebek LRT and Padalarang Station integrated with Feeder Train or feeder train with a route from Padalarang Station to Bandung Station, which is taken in less than 15 minutes; Commuter Line Garut, and Commuter Line Bandung Raya.

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Efforts High-speed railways have great potential to increase economic growth in the areas they pass, especially regions that become transit points or train stops. Connectivity between cities can support economic activities such as trade and investment to develop faster. For example, Tegalluar Station was chosen as one of the stops of the Jakarta Bandung High-Speed Train; the selection of this location was based on considerations to increase economic development by taking into account the investment potential and development of the region (Yusuf, 2022). This aims to ensure that the Tegalluar area can continue to develop and not be left far behind from the advanced Bandung City center.

Figure 1. Plans for the Continuation of the High-Speed Rail Line in Indonesia

In accordance with the 2030 National Railway Master Plan (RIPNAS) on the railway network plan on the island of Java, the construction of high-speed railways in Indonesia will continue to the city of Surabaya so that it has a Jakarta-Surabaya travel route. For now, the construction of high-speed rail facilities only exists from Jakarta to Bandung (KCJB). The continued development of the Jakarta Bandung High-Speed Railway will continue to Surabaya through one of the options, namely the northern route (Bandung-Cirebon-Semarang-Surabaya), which can be seen in Figure 1. The existence of previous research that discusses the geometry planning of the continued route of the Jakarta Bandung High-Speed Railway with the title “Geometry Planning of the Bandung-Cirebon Phase I (Rancaekek-Cimalaka) High-Speed Railway Line,” the author is interested in continuing the research. The Cirebon-Brebes section is the next required section to realize the Jakarta-Surabaya High-Speed Railway. The construction of a high-speed railway line on this crossing will improve connectivity between cities and facilitate the mobility of residents and goods.

This research aims to select the best trajectory with a simple multi-criteria analysis through the approach of disaster aspects and land use using ArcGIS 10.8 for the Cirebon-Semarang Phase I (Cirebon-Brebes) high-speed railway line. ArcGIS 10.8 is a software developed by the Environmental Systems Research Institute (ESRI) that functions to manage, analyze, and visualize geographic data. Selection of the best route using ArcGIS 10.8 application with the approach of disaster and land use aspects can provide more detailed and clear results

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2. Research Methods

2.1 Data Collection Methods

A. Topographic Map Data

Peta Topographic map is a map that shows the state and shape of the Roman disguise of the earth's face and its dimensions. Topographic data contains contour maps used to plan vertical alignments in geometry planning. A contour line combines two related but not intersecting line segments that indicate an area elevation. You can use Google Earth Pro software to get elevation information on a path by adding a new path and then selecting the “Show Elevation Profile” option. When you have selected the option, you will see an elevation graph and some information, including minimum elevation, maximum elevation, average elevation, maximum slope, addition and subtraction of elevation, and average slope.

B. Land Use Data

Data Land use data includes land use data in an area that will be used to plan horizontal alignments and as a basis for multi-criteria analysis to determine the best route. This land use data is obtained from the website https://tanahair.indonesia.go.id/ on the map menu per region; the data can be downloaded according to the area needed.

C. Disaster Map

The disaster map contains disaster data of an area in the form of a disaster risk index for floods, flash floods, landslides, volcanic eruptions, tsunamis, and extreme weather, which will later be used for multi-criteria analysis to determine the best route. The disaster map is obtained from the official portal of the National Disaster Management Agency (BNPB), which contains the results of a risk assessment using ArcGis server as data services, namely https://inarisk.bnpb.go.id/.

2.2 Data Processing Method

A. Topographic Map Data

Data Topographic map data or elevation data used for multi-criteria analysis is obtained from Google Earth software with the “Show Elevation Profile” tool, which shows the height and slope of a path. The smaller the slope value displayed on Google Earth Pro, the better the trajectory plan. Then, to get a contour of the area used for the geometry and path planning stage in AutoCAD Civil 3D, the first step is to prepare DEMNAS data obtained from the website https://tanahair.indonesia.go.id/, which is then input into the Global Mapper software. The second step is to create a polygon in Google Earth software covering the area where you want to know the contours and elevations. After that, the polygon can be inputted into the Global Mapper software, which inputs DEMNAS data. Then, we will use the Digitizer Tool to cut the extensive DEMNAS data into the polygon area of Google Earth Pro that we want. The last step is to generate contours, which will bring up the contours of the selected area. To be imported into AutoCAD Civil 3D, the contour results in Global Mapper must be exported using the export vector option, and then the DWG file type must be selected.

B. Land Use Data

Land use data obtained from the website https://tanahair.indonesia.go.id/ is inputted into ArcGIS 10.8 software and continued processing. This land use data will be combined with Indonesia's district/city boundary data. They will be taken from three areas, namely Brebes Regency, Cirebon

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Regency, and Cirebon City, by the area passed by the trade plan so that the land use crossed by the trade plan can be seen. The final result of processing land use data is that it will be seen how much settlement area is passed by each alternative route using the measure tool in ArcGIS 10.8. The fewer settlements that are traversed, the better the trajectory plan because the land acquisition costs are lower.

C. Disaster Map

In this research, natural disasters include floods, flash floods, landslides, volcanic eruptions, tsunamis, and extreme weather. The disaster map data obtained will be processed using ArcGIS 10.8 software. Data obtained from BNPB's website https://inarisk.bnpb.go.id/ in the form of files containing disaster maps throughout Indonesia for each type of natural disaster that can be directly input into ArcGIS 10.8 software. In processing the disaster map, data will be combined with data on district/city boundaries throughout Indonesia. They will be taken in 3 areas, namely Brebes Regency, Cirebon Regency, and Cirebon City, by the area traversed by the trade plan. The final result of this data processing is that each alternative trajectory will pass through disaster-prone areas with safe or unsafe risks using the measure tool in ArcGIS 10.8, which will then be included in a simple multi-criteria analysis assessment.

2.3 Data Processing Method

The selection of the best trajectory in this study uses a simple multi-criteria analysis method. This simple multi-criteria analysis uses an assessment with a ranking system for each aspect. Three alternative trajectory plans were selected to be included in the assessment and ranking of multi-criteria analysis by considering aspects of regional topography, aspects of disaster and land use processed using ArcGIS 10.8, the number of vertical and horizontal alignments, and aspects of network integration and accessibility for consideration of the station point. The secondary data will be processed and analyzed using a simple multi-criteria analysis to determine the best trajectory. Topographic map data shows how many inclines or vertical alignments will be formed on a trajectory. The more gentle the speed of high-speed trains will be maximized. Land use data is used to estimate how expensive land acquisition will be because the price of land acquisition of settlements with rice fields is certainly different, so the less residential land through the trajectory plan, the better. Disaster data is used to see the trade plan through disaster-prone areas with low to high risk; if the trade plan does not pass through disaster-prone areas with high risk, the trade plan will be better.

3. Result and Discussion

3.1 Alternative Route

The starting point of this research uses the coordinates from Civil 3D software at the end point of the previous research, namely x: 225367.1219 and y: 9254864.2858, with the kilometer station Km 100 + 685.72. The endpoint of this research is located at Tanjung Station, Brebes Regency. The selection of the endpoint is based on the existing conditions at Tanjung Station, namely around it, there are still many lands that are not residential land, and the location of Tanjung Station is quite strategic (9 km to toll road access, 2 km to the bus terminal, and 20 km to the center of Brebes Regency).

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Table 1 Detail of Alternative Trace Selection

Name	Starting Point	End Point	Reason
Alternatif Trase 1	Previous Research Endpoint	Tanjung Station	Follows The Toll Road
Alternatif Trase 2	Previous Research Endpoint	Tanjung Station	Cuts the Center (Between Pantura Road and Palikanci Toll Road)
Alternatif Trase 3	Previous Research Endpoint	Tanjung Station	Follows the Existing Line of Conventional Railway

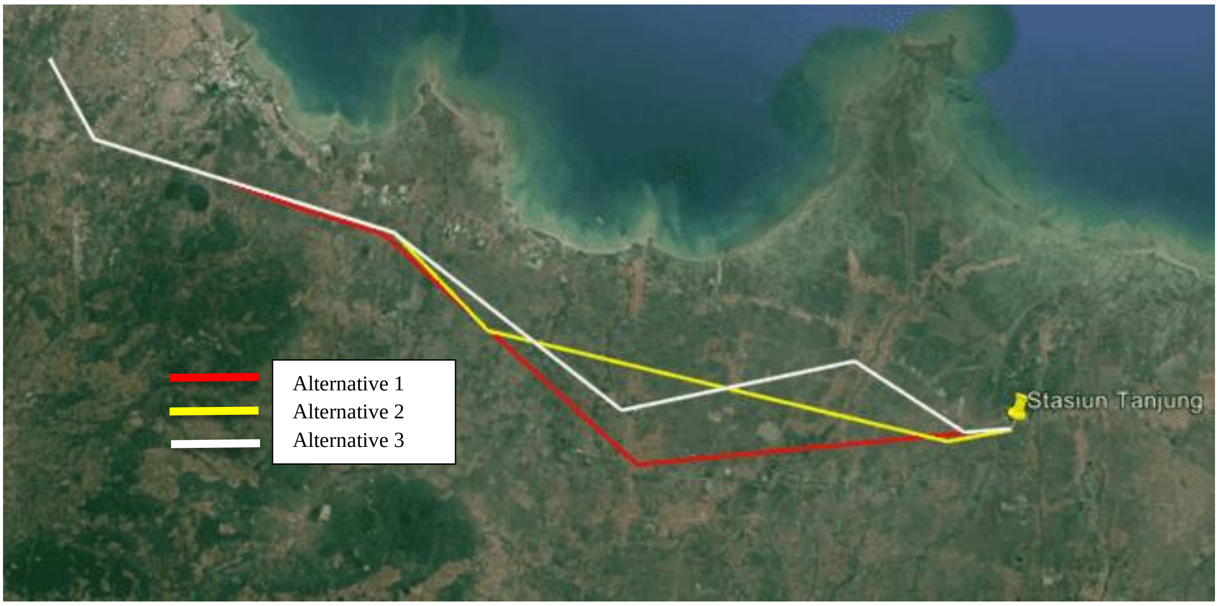

Figure 2. Alternative Trace

3.2 Simple Multi-criteria Analysis

Multi-criteria analysis can be applied simply by comparing the performance of each alternative route against several aspects of the specified selection criteria. Alternatives with higher ratings on several criteria will be more likely to be selected and implemented. The method of assessment is done by giving a value based on ranking. In this study, ranking 1 gets a value of 3, ranking 2 gets a value of 2, and ranking 3 gets a value of 1. (Rosyidi, 2015)

A. Construction Aspect

The construction aspect includes the track's length, the construction type, and the number of horizontal curves on each selected alternative trajectory. In this study, the type of construction used is elevated. The following is an analysis of the construction aspects of each alternative route:

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Figure 3. Construction Aspect Analysis (Google Earth Pro)

Table 2 Result of Construction Aspect Analysis

No	Aspect Analysis	Alternative 1	Alternative 2	Alternative 3	Assessment Basis
1	Line Length (Km)	44,6 Km	43,2 Km	44,4 Km	Shorter
2	Construction Type	*Elevated*	*Elevated*	*Elevated*	*At Grade, Elevated, Tunnel*
3	Number of Horizontal	3	4	5	Fewer

B. Disaster Aspects

The disaster aspects include floods, flash floods, tsunamis, landslides, volcanic eruptions, extreme weather, and earthquakes. The disaster data used is 2021 disaster data obtained from the website owned by BNPB (National Disaster Management Agency) https://inarisk.bnpb.go.id/. The data obtained is then analyzed using ArcGIS 10.8 by measuring safe or unsafe areas and then producing a percentage of the length of the safe area traversed by each alternative route from the overall length of each alternative route. The following are the results of the analysis of several aspects of disaster on each alternative route:

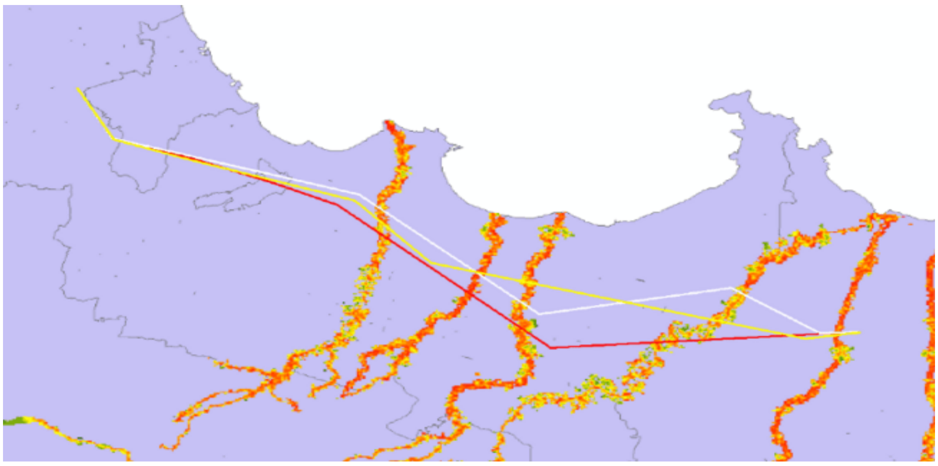

Figure 4 Analysis of Disaster Aspects

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Table 3 Result of Disaster Aspect Analysis

No	Aspect Analysis	Alternative 1	Alternative 2	Alternative 3	Assessment Basis
1	Flood	30 % Safe Zone	22,7 % Safe Zone	20 % Safe Zone	Higher Percentage
2	Flash Flood	87 % Safe Zone	95 % Safe Zone	93 % Safe Zone	Higher Percentage
3	Tsunami	100 % Safe Zone	100 % Safe Zone	100 % Safe Zone	Higher Percentage
4	Landslide	100 % Safe Zone	100 % Safe Zone	100 % Safe Zone	Higher Percentage
5	Volcanic Eruption	99,3 % Safe Zone	99,2 % Safe Zone	99,3 % Safe Zone	Higher Percentage
6	Extreme Weather	0 % Safe Zone	0 % Safe Zone	0 % Safe Zone	Higher Percentage
	Average	69,4 % Safe Zone	69,5 % Safe Zone	68,7 % Safe Zone	Higher Percentage

C. Land Use Aspects

The land use aspect considered is how much land functions as a settlement. Land used as settlements will be more expensive in land acquisition, and the process will be more complicated because it deals directly with the community. So it would be better if the path avoids residential areas. Land use data is obtained on maps per region from the website https://tanahair.indonesia.go.id/. Processing to obtain the area of settlements passed by alternative trajectories using ArcGIS 10.8 by measuring the length of the area passing through the settlement and multiplying by 24.6 m (12.3 m to the left of the track axle and 12.3 m to the right of the track axle) by PM No. 11/2012 on the procedures for determining the railway line trajectory. The following are the results of the analysis of the land use aspects of each alternative route:

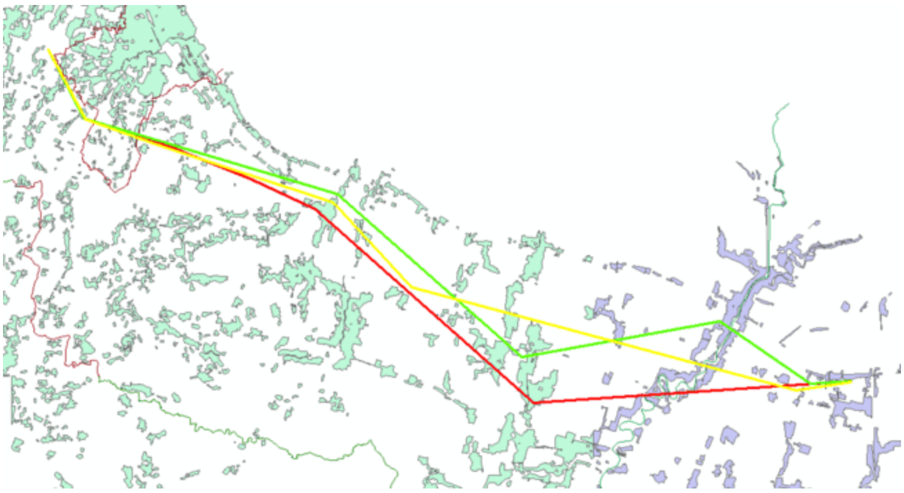

Figure 5. Land Use Aspect Analysis (ArcGIS 10.8)

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Table 4 Results of Land Use Aspect Analysis

No	Aspect Analysis	Alternative 1	Alternative 2	Alternative 3	Assessment Basis
1	Settlement Area (m²)	340.464 m²	282.470 m²	309.173 m²	Smaller Area

D. Topographical Aspects

In this study, the topographic aspects used to assess simple multi-criteria analysis are the average slope and maximum slope of each alternative route obtained from Google Earth Pro in the form of percent (%). The smaller the percentage, the better. The following is the analysis of the topographic aspects of each alternative route:

Figure 6. Topography Aspect Analysis (Google Earth Pro)

Table 5 Results of Topography Aspect Analysis

No	Aspect Analysis	Alternative 1	Alternative 2	Alternative 3	Assessment Basis
1	Average Slope	0,7%	0,7%	0,6%	Smaller Percentage
2	Maximum Slope	10,3%	10,4%	11,7%	Smaller Percentage

E. Simple Multi-criteria Analysis Results

After knowing the analysis of each aspect of the assessment, the next step is to make an assessment according to the ranking obtained in each aspect. The following are the results of the assessment using simple multi-criteria analysis:

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Table 6 Simple Multi-criteria Analysis Assessment Results

No	Aspect Analysis	Alternative 1	Alternative 2	Alternative 3
	Construction Aspect			
1	Track Length	1	3	2
2	Construction Type	3	3	3
3	Number of Horizontal Curves	3	2	1
	Aspects of Disaster			
1	Flood	3	2	1
2	Flash Flood	1	3	2
3	Tsunami	3	3	3
4	Landslides	3	3	3
5	Volcanic Eruption	3	2	3
6	Extreme Weather	1	1	1
	Land Use Aspects			
1	Settlement Area	1	3	2
	Topographic Aspects			
1	Average Slope	2	2	3
2	Maximum Slope	3	2	1
	Total	**27**	**29**	**25**

4. Conclusion

Based on the results of the analysis in this study, it can be concluded as follows:

1) The Cirebon—Semarang phase 1 (Cirebon—Brebes) high-speed rail line is made with a starting point continuing previous research and an endpoint at Tanjung Station (Brebes). Three alternative trajectories are made to be considered through simple multi-criteria analysis. The three alternative trajectories are made by following the Pantura Road, Palikanci Toll Road, and cutting the middle between the Pantura Road and Palikanci Toll Road.
2) Penelitian This research considers the results of analyzing aspects of disaster, topography, construction, and land use using a simple multi-criteria analysis method to determine the best alternative route. The analysis of disaster and land use aspects uses ArcGIS 10.8 software to process the data obtained. In accordance with the results of a simple multi-criteria analysis, alternative 2, with a path length of 43.2 km, was chosen as the best alternative trajectory.

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