Application of the *Composite Performance Index* (CPI) Method in Optimizing the Location Point of the Goods Terminal in Banyuwangi Regency

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Abstract

Banyuwangi Regency is an area that is traversed by two goods transport routes on the island of Java, so that the movement of goods transportation in Banyuwangi Regency continues to increase and causes goods transportation problems such as illegal parking of goods on the side of the road and the loading and unloading process on the road. The goods terminal is a transportation node that is used to carry out loading and unloading activities, transfer of goods transportation modes, consolidation of goods, and parking of goods cars. This research aims to determine the location point of the goods terminal in Banyuwangi Regency. The research method in this study uses the Composite Performance Index (CPI) with four criteria, namely road section performance, accessibility, environmental sustainability, and initial investment costs. The results of the research on determining the location point of the goods terminal in Banyuwangi Regency found that alternative location 1 on the Argopuro Road section is the best location by obtaining a final calculation of 192.77, while for alternative location 2 on the Situbondo-Banyuwangi Highway section obtained a final value calculation of 171.68, and alternative location 3 on the Jember-Banyuwangi Highway section obtained a final value calculation of 121.01. Based on the results of the research, alternative location 1 is the recommended location as the location point for the construction of the goods terminal in Banyuwangi Regency.

Keywords: Accessibility; Environmental sustainability; Goods terminal; Initial investment cost; Road section performance

1. Introduction

Banyuwangi Regency is an area traversed by two goods transport routes on the island of Java, thus affecting the level of goods movement and causing goods transportation problems in Banyuwangi Regency such as illegal parking of goods transport on the roadside and the loading and unloading process on the road. The increase in the volume of goods vehicles due to the existence of two cross goods routes also has an impact on the movement of goods flow at transportation nodes, especially goods in Banyuwangi Regency such as Tanjung Wangi Port. Tanjung Wangi Port has a fairly high level of goods movement where every year there are loading and unloading activities of more than one million tons of goods: [1]. The Banyuwangi Regency Government is committed to the construction of the Trans Java exit toll in Banyuwangi Regency and in accordance with the Banyuwangi Regency Regional Spatial Plan related to the development plan for goods transportation infrastructure in the form of a cargo terminal as a facility provided and an effort to overcome the problem of goods transportation in Banyuwangi Regency: [2]. Based on the identification of goods transportation problems in Banyuwangi Regency, this study aims to analyze the calculation of criteria for determining the location point of the goods terminal in Banyuwangi Regency and produce recommendations for the location point of the goods terminal based on the results of the final calculation using the Composite Performance Index (CPI) method which is considered appropriate because in calculations it uses objective data from each choice without the influence of other people's point of view or subjectivity, in addition this method can also adjust the number of criteria to be used and various trends in each criterion.

The analysis of determining the location point of the goods terminal refers to Regional Regulation Number 8 of 2012 concerning the Banyuwangi Regency Regional Spatial Plan related to the development of goods transportation infrastructure in the form of cargo terminals in Banyuwangi

Regency and Minister of Transportation Regulation Number 120 of 2018 concerning the Implementation of Goods Terminals regarding several things that need to be considered in determining the location point of the goods terminal such as criteria and other provisions. In determining the location point of the goods terminal, there is an analysis that needs to be done, namely the performance of road sections, accessibility, environmental sustainability, and initial investment costs. There are three alternative location for goods terminal in Banyuwangi Regency which are obtained by following the Regional Regulations governing this matter and adjusted to the results of field observations at the three alternative locations for goods terminal that have problems with freight transportation, so that these location are suitable for the location of goods terminal, namely alternative location 1 Argopuro Warehousing on the Argopuro Road section, alternative location 2 Sritanjung Terminal on the Situbondo-Banyuwangi Highway section, and location alternative 3 Wiroguno Terminal on the Jember-Banyuwangi Highway section.

2. Methods

The method used in this research is the Composite Performance Index (CPI) in the form of a calculation analysis to solve decision-making problems based on a combined index with the calculation results in the form of a ranking of all alternative choices: [3]. The data sources needed are primary data and secondary data, where primary data includes an inventory of road sections, alternative locations for goods terminals, traffic counting results obtained directly during field observations at alternative locations, while secondary data are in the form of road type certificates, data on the number of vehicles, road network maps, land use maps, population density maps, and Banyuwangi Regency regional spatial planning plans obtained during audiences with the relevant government, namely the Banyuwangi Regency Transportation Office.

Data analysis is carried out based on criteria that are adjusted to the provisions governing the goods terminal, namely the Minister of Transportation Regulation Number 102 of 2018 concerning the Implementation of Goods Terminals, several things that need to be considered in determining the location point of the goods terminal and are used as criteria, namely road section performance, accessibility, environmental sustainability, and initial investment costs: [4]. The criteria used have different weightings according to the conditions of the research location and the needs of the location, based on: [5], the weighting of each criteria can be determined based on the results of interview with sources so as to get the weighting of the criteria values as in Table 1.

Table 1. Weighting of Goods Terminal Location Criteria

No.	Criteria	Weighting
1.	Road Section Performance	0,36
2.	Accessibility	0,30
3.	Environmental Sustainability	0,20
4.	Initial Investment Cost	0,14

Table 1, it is known that the performance of road sections is the criterion with the highest weighting because it is considered to have a major influence on goods terminal activities and is related to accessibility, then for the environmental sustainability of the research location there are still many vacant land uses and initial investment costs which are influenced by the ownership of the alternative location: [6]. There are differences in the analysis of each criterion in this study, namely:

2.1. Road Section Performance Criteria

Analysis of road section performance criteria has two sub-criteria, namely capacity and v/c ratio *of* alternative location road sections, road section performance is a measurement of a condition of the road section based on road section performance indicators such as capacity and v/c ratio: [7]. The capacity sub-criteria use primary data based on the results of the road section inventory survey to obtain the results of the road section capacity calculation which is written as in Equation 1 below.

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK} \tag{1}$$

C : Road section capacity (smp/hour)
C_0 : Basic capacity for certain/ideal conditions (smp/hour)
FC_{LJ} : Traffic lane width adjustment factor
FC_{PA} : Direction separation adjustment factor
FC_{HS} : Side obstacle adjustment factor
FC_{UK} : City size adjustment factor

As for the v/c ratio sub criteria, the next primary data is related to the results of traffic counting to obtain vehicle volume data on the road section, then the v/c ratio calculation will be carried out and written as Equation 2 below.

$$V/C\ Ratio = \frac{\text{Vehicle Volume (SMP/hour)}}{Road\ Capacity} \tag{2}$$

2.2 Accessibility Criteria

The accessibility criteria analysis has three sub-criteria in the form of distance measurements to several location points, namely transportation nodes, government centers, and trade centers. Accessibility is a measure of the ease of a location to be reached from other locations using transportation modes and a measure of affordability, namely distance, time, and effort in making a move: [8]. Accessibility criteria pay attention to transportation networks and the suitability of road networks in alternative locations: [9]. Accessibility analysis will use the help of QGIS software to display isochrones maps with a range of 1000 m, 3000 m, and 5000 m from alternative locations because the location of the good terminal can be integrated with several supporting locations according to expectations of the Banyuwangi Regency Regional Regulations.

2.3 Environmental Sustainability Criteria

Analysis of environmental sustainability criteria has three sub-criteria in the form of measuring the distance to several location points, namely river flow, residential areas, and industrial areas. Environmental sustainability is an effort made to maintain and maintain the environment in order to maintain the continuity of life: [10]. The analysis of environmental sustainability still uses the help of QGIS software to display isochrones maps with a range of 1000 m, 3000 m, and 5000 m from alternative locations to river flows in flood-prone assessments, residential areas in noise-prone assessments, and industrial areas in pollution-prone assessments.

2.4 Initial Investment Cost Criteria

Initial investment cost criteria analysis is an analysis that needs to be taken into account because it is the cost incurred when making a purchase or running a project or business in the first year: [11]. The initial investment cost analysis uses the help of the Bhumi website issued by the Ministry of ATR / BPN so that it can display a map of the land value zone of each alternative location and obtain a range of land price values at that location.

2.5 CPI Calculation Analysis

The final calculation analysis after obtaining the value of the four criteria on all alternative locations will be calculated using the Composite Performance Index method, the CPI calculation for each criterion will later be adjusted to the trend of the criteria, if the trend is positive the highest value will be used as a divisor and in a negative trend the lowest value will be used as the value divided by the value of the alternative location, the following is a CPI analysis diagram as in Figure 1 below.

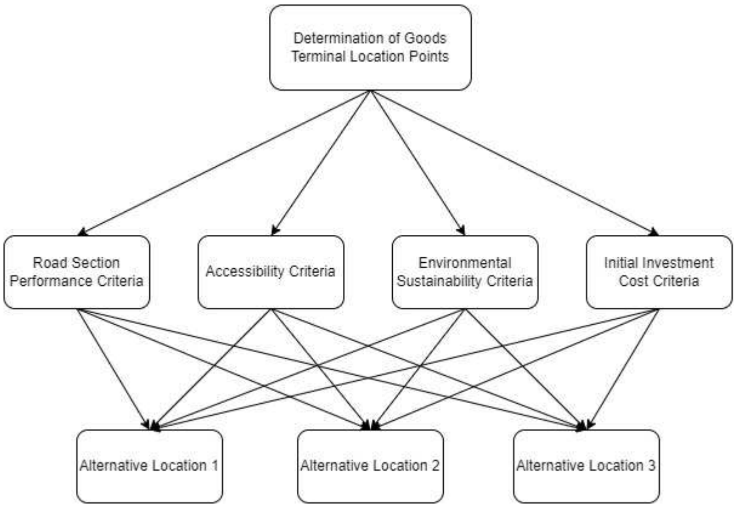

Figure 1. *Composite Performance Index* Analysis

Figure 1, the analysis diagram of the Composite Performance Index method is shown with the calculation of the four criteria carried out at each alternative location. The three alternative locations are locations obtained from regional regulations that regulate and are in accordance with the results of field observations so that the three locations are obtained. Based on: [12], the final calculation in this method has several stages of calculation such as the following equations 3-6.

$$A_{ij} = \left(\frac{x_{ij}(\text{min/positive})}{x_{ij}(\text{min/positive})}\right) \times 100 \tag{3}$$

$$A_{(i+1.j)} = \left(\frac{x_{(i+1.j)}(\text{min/positive})}{x_{ij}(\text{min/positive})}\right) \times 100 \tag{4}$$

$$A_{(i+1.j)} = \left(\frac{x_{(i+1.j)}(\text{min/positive})}{x_{ij}(\text{min/positive})}\right) \times 100 \tag{5}$$

$$I_i = \sum_{i=1}^{n} I_{ij} \tag{6}$$

Information:

A_{ij}	: The value of the i-th alternative on the j-th criterion
$x_{ij}(\text{min/positive})$	: Minimum/maximum value of i-th alternative on j-th criterion
$A_{(i+1.j)}$	: The value of the i+1st alternative on the jth criterion
$x_{(i+1.j)}$	: The value of the i+1st alternative on the jth initial criterion
P_j	: Weight on each criterion
I_{ij}	: The resulting alternative index value
I_i	: The resulting composite index value

3. Results and Discussion

In the results and discussion there are the results of the calculation of the four criteria for three alternative locations for determining the location of the goods terminal in Banyuwangi Regency, the three alternative locations are displayed with colored dot that are determined based on the result of field observations of the three locations that have problems with freight transportation, the three alternative locations can be seen in Figure 2 below.

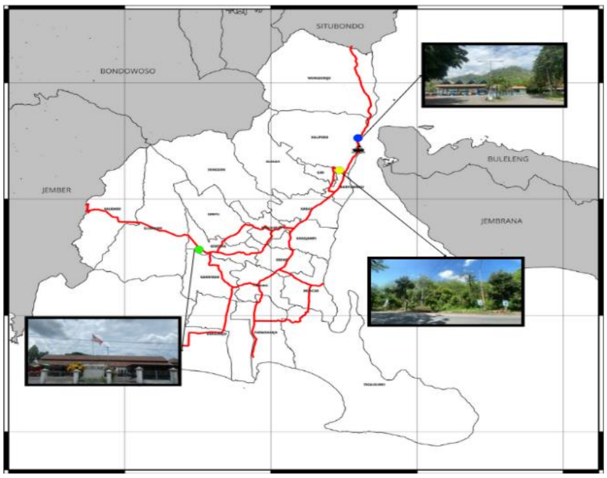

Figure 2. Alternative Location of Goods Terminal

Figure 2, each alternative location is shown, namely alternative location 1 Argopuro Warehousing on the Argopuro Road section yellow dot, alternative location 2 Sritanjung Terminal on the Situbondo-Banyuwangi Highway section blue dot, and alternative location 3 on the Jember-Banyuwangi Highway section green dot. The yellow and blue dots are alternative location 1 and 2 obtained from Regional Regulation Number 6 of 2012 concerning the Banyuwangi Regency Spatial Planning Plan for 2012-2036 as representatives of each Kalipuro and Wongsorejo sub-district, and for the green dot which is alternative location 3 obtained from the result of an audience with related institutions, namely the Banyuwangi Regency Transportation Office.

3.1 Road Section Performance Criteria

The calculation of the performance of road sections uses several indicators, namely capacity and degree of saturation or v/c ratio: [13]. The capacity of the road section which is the alternative location point of the goods terminal in Banyuwangi Regency is obtained after all the correction factor values on the road section are adjusted in accordance with the Indonesian Road Capacity Guidelines related to the calculation of road section capacity, so that the results of the capacity calculation are obtained as in Table 2 below.

Table 2. Alternative Location Road Section Capacity

Street Name	Capacity Calculation	Yield (SMP/hour)
Argopuro Street	C = 2800 x 1,25 x 1 x 0,92 x 1	3220
Situbondo – Banyuwangi Highway	C = 2800 x 1,34 x 1 x 0,94 x 1	3526,88
Jember – Banyuwangi Highway	C = 2800 x 0,87 x 1 x 0,94 x 1	2289,84

Table 2, the results of the calculation of the capacity of the road section which is the alternative location of the freight terminal are shown, the road section with the highest capacity is obtained by the Situbondo-Banyuwangi Highway section with a value of 3526.88 SMP/hour. Next, the calculation is carried out to obtain the results of the v/c ratio sub criteria by comparing the volume of vehicles (SMP /hour) and the capacity of the road section, so that the calculation results are obtained as in Table 3 below.

Table 3. V/C Ratio of Alternative Location Road Sections

Street Name	Calculation of *V/C Ratio* = SMP/jam / C0	*V/C Ratio*
Argopuro Street	*V/C Ratio* = 1602,1 / 3220	0,4975466
Situbondo – Banyuwangi Highway	*V/C Ratio* = 1790,8 / 3526,88	0,5077576
Jember – Banyuwangi Highway	*V/C Ratio* = 1680,6 / 2289,84	0,7339377

In Table 3, the results of the calculation of the degree of saturation or v/c ratio of the alternative location of the freight terminal and the road section that has the lowest v/c ratio is the Argopuro Road section with a value of 0.49.

3.2 Accessibility Criteria

Calculation of analysis on accessibility criteria is carried out with the help of QGIS software isochrones map so as to get the distance in kilometers and travel time in minutes of alternative location with supporting locations such as transportation nodes, government centers, and trade centers. Alternative location 1 based on isochrones map analysis obtained distance and travel time as shown in Table 4 below.

Table 4. Accessibility of Alternative Site 1

Argopuro Warehousing Location Point			
Transportation Nodes			
No.	**Name**	**Distance (km)**	**Time (Minutes)**
1.	Blambangan Terminal	2,30 km	4 Minutes
2.	Boom Harbor	5,10 km	13 Minutes
Government Center			
1.	Kalipuro Subdistrict	1,60 km	3 Minutes
2.	Giri Subdistrict	4,80 km	9 Minutes
3.	Kota Subdistrict	5,00 km	12 Minutes
Trade Center			
1.	Blambangan Market	2,20 km	4 Minutes
2.	Banyuwangi Big Market	3,50 km	7 Minutes

Table 4, displays the results of the analysis in the form of distance in kilometers and travel time in minutes for alternative location 1 on Argopuro Road. Next, alternative location 2 based on the results of the isochrones map analysis, the distance and travel time data are obtained as in Table 5 below.

Table 5. Accessibility of Alternative Site 2

Sritanjung Terminal Location Point			
Transportation Nodes			
No.	**Name**	**Distance (km)**	**Time (Minutes)**
1.	Tanjung Wangi Port	1,3 KM	3 Minuets
2.	Ketapang Port	2,7 KM	6 Minutes
3.	LCM Port	3,2 KM	7 Minutes
4.	Ketapang Station	2,60 km	6 Minutes
Government Center			
1.	BPTD Satpel Port	3,40 km	7 Minutes
Trade Center			
1.	Ketapang Market	3,10 km	8 Minutes

Table 5, displays the results of the analysis in the form of distance in kilometers and travel time in minutes for alternative location point 2 on the Situbondo-Banyuwangi Highway section. Alternative location 3 based on the results of the isochrones map analysis, the distance and travel time data are obtained as in Table 6 below.

Table 6. Accessibility of Alternative Site 3

Wiroguno Terminal Location Point			
Transportation Nodes			
No.	**Name**	**Distance (km)**	**Time (Minutes)**
1.	-	-	-
Government Center			
1.	Genteng Subdistrict	4,50 km	10 Minutes
Trade Center			

Wiroguno Terminal Location Point			
1.	Genteng Wetan Market	3,70 km	8 Minutes
2.	Genteng Market	2,70 km	6 Minutes

Table 6 shows the results of the analysis in the form of distance in kilometers and travel time in minutes for alternative location 3 on the Jember-Banyuwangi Highway.

3.3 Environmental Sustainability Criteria

Calculation of environmental sustainability criteria analysis is carried out with the help of QGIS software isochrones map so as to get the distance in kilometers of alternative locations to several locations such as river flows, residential areas, and industrial areas. Alternative location 1 based on isochrones map analysis obtained the distance in kilometers as in Table 7 below.

Table 7. Environmental Sustainability of Alternative Site 1

Argopuro Warehousing Location Point		
River Flow		
No.	**Name**	**Distance (km)**
1.	South River	0,68 km
2.	North River	1,00 km
Residential Area		
1.	Argopuro Settlement	0,35 km
Industry		
1.	Cosmetic Industry	2,60 km
2.	Shipbuilding Industry	1,90 km
3.	Bosowa Cement Industry	4,20 km

Table 7, it is known that the distance in kilometers of alternative location 1 with several locations related to environmental sustainability around it. Next, alternative location 2 based on isochrones map analysis obtained the distance in kilometers as in Table 8 below.

Table 8. Environmental Sustainability of Alternative Site 2

Sritanjung Terminal Location Point		
River Flow		
No.	**Name**	**Distance (km)**
1.	South River	1,10 km
2.	NorthRiver	1,85 km
Residential Area		
1.	Back Settlement	0,17 km
Industry		
1.	Gresik Cement Industry	0,75 km
2.	Sriwijaya Fertilizer Industry	1,70 km
3.	INKA Railway Industry	3,90 km

Table 8, the distance of alternative location 2 with several locations related to environmental sustainability in the vicinity is known. At the last alternative location, namely alternative location 3 based on isochrones map analysis, the distance in kilometers is obtained as in Table 9 below.

Table 9. Environmental Sustainability of Alternative Site 3

Wiroguno Terminal Location Point		
River Flow		
No.	**Name**	**Distance (km)**
1.	East River	0,23 km
2.	West River	0,78 km
Residential Area		

Wiroguno Terminal Location Point		
1.	Wiroguno Settlement	0,48 km
Industry		
1.	Coconut Shell and Charcoal Industry	4,10 km
2.	Tofu and Tempeh Industry	5,00 km
3.	Building Materials Industry	1,30 km

Table 9, the distance in kilometers of alternative location 3 with several locations related to environmental sustainability around it is known.

3.4 Initial Investment Cost Criteria

Analysis on the initial investment cost criteria was carried out with the help of the Bhumi website so that it displays a map of the land value zone of each alternative location of the goods terminal in Banyuwangi Regency. The following is a map of the land value zone at alternative location 1 as shown in Figure 3 below.

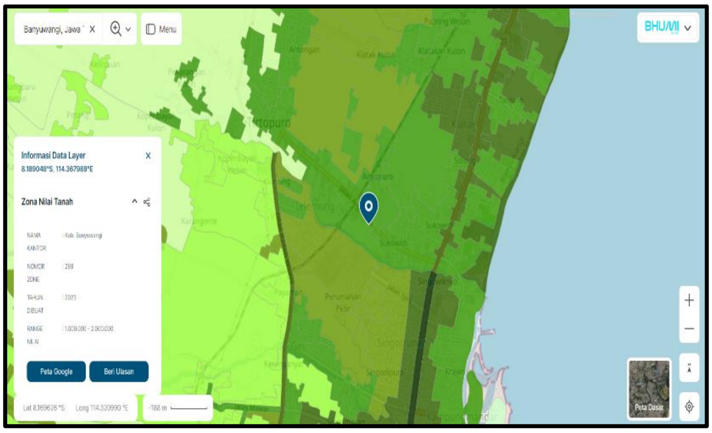

Figure 3. Land Value Zona Map of Alternative 1

Figure 3, a map of the land value zone of alternative location 1 is displayed so that it is known that the range of land values at alternative location 1 is IDR 1,000,000 - IDR 2,000,000 /m^2. The next display of the land value zone map of alternative location 2 is as shown in Figure 4 below.

Figure 4. Land Value Zone Map of Alternative 2

Figure 4, displays a map of the land value zone of alternative location 2 so that it is known that the range of land values at that location is IDR 2,000,000 - IDR 5,000,000 /m^2. Furthermore, the map display of the land value zone at the last alternative location, namely alternative location 3 as in Figure 5 below.

Figure 5. Land Value Zona Map of Alternative Site 3

Figure 5, displays a map of the land value zone of alternative location 3 so that it is known that the range of land price values at that location is IDR 200,000 - IDR 500,000 /m^2.

3.5 Composite Performance Index Analysis

Calculation of the Composite Performance Index method in determining the location point of the freight terminal based on the results of the analysis of the four criteria with each trend towards the three alternative locations. The calculation of the value of the positive trend and negative trend sub criteria is done by making the highest value in the positive trend as the divider value and the lowest value in the negative trend as the divided value and later continued by multiplying the weighting criteria and summing up the final results. The calculation of the Composite Performance Index can be seen in Table 10 below.

Tabel 10. Composite Performance Index Calculation

Criteria	Weighting	Alternative Location									Trends
		Alternative Location 1			Alternative Location 2			Alternative Location 3			
Road Section Performance	**0,36**	**Value**	**Value Transformation**	**Location Value**	**Value**	**Value Transformation**	**Location Value**	**Value**	**Value Transformation**	**Location Value**	
Capacity	(smp/hour)	3220	91,30	32,87	3526,88	100	36	2289,84	64,93	23,37	Trend +
V/C Ratio		0,5	100	36,00	0,51	98,04	35,29	0,73	68,49	24,66	Trend -
Accessibility	0,30										
Distance to transportation Nodes	(km)	2,3	56,52	16,96	1,30	100,00	30,00	-	-	-	Trend -
Distance to Government Center		1,6	100	30,00	3,40	47,06	14,12	4,50	35,56	10,67	
Distance to Trade Center		2,2	100	30,00	3,10	70,97	21,29	2,70	81,48	24,44	
Environmental Sustainability	0,2										
Distance to River	(km)	0,68	61,82	12,36	1,10	100	20	0,23	20,91	4,18	Trend +
Distance to Settlement		0,35	72,92	14,58	0,17	35,42	7,08	0,48	100	20	
Distance to Industry		1,9	100	20,00	0,75	39,47	7,89	1,30	68,42	13,68	
Initial Investment Cost	0,14										
Land Price	(/m^2)	IDR 2.000.000	25	3,50	IDR 5.000.000	10	1,40	IDR 500.000	100	14,00	Trend -
TOTAL		**192,77**			**171,68**			**121,01**			Trend +

In Table 10, is a CPI calculation table where each criteria have a different trend, the trend is obtained based on each analysis of the location value sub-criteria, where when the value is higher the better than the sub-criteria is classified as a positive trend (+), while for sub-criteria with a lower value the better means including a negative trend (-). Table 10, displays the results of the final calculation of all existing criteria and it is known that alternative location 1 is an alternative location with the highest value of 192.77, then in second place is alternative location 2 with a value of 171.68, and alternative location 3 gets a value of 121.01. Seeing the results of the calculation, alternative location 1 is the recommended alternative location as the location point for the goods terminal in Banyuwangi Regency.

Based on the Minister of Transportation Regulation Number 120 of 2018 concerning the Implementation of Goods Terminals, it is said that there are several things that must be considered in determining the location of goods terminals, namely the level of accessibility of transport road users, land suitability with spatial plans, road classes, compatibility with development plans and performance and road networks, compatibility with development plans and activity centers, compatibility with the national logistics system, demand for freight transportation, distribution patterns, technical, financial and economic feasibility, security and safety of road transport traffic, and preservation of environmental functions. The nine aspects do not have a specific weighting so that all nine aspects must be considered: [14].

Evidently in this study the calculation of the value of alternative location 2 is superior in several criteria, but in other criteria it has a low value so that in the final results alternative location 2 ranks second. In contrast to alternative location 1 which excels in several criteria, while for other criteria only a few values are adrift, making alternative location 1 the location with the highest value.

Based on: [14], it is stated that in determining the location of the goods terminal must pay attention to the generation of the largest load or the level of accessibility of the location. In accordance with this statement, this study considers the level of accessibility of alternative locations and obtains alternative location 1 as the location with the best level of accessibility. Alternative location 1 gets a value of 76.96, while for alternative location 2 and alternative location 3 get a value of 65.41 and 35.11 respectively. This also makes alternative location 1 the recommended location as the location of the goods terminal in Banyuwangi Regency.

The calculation analysis on accessibility criteria in this study has differences with other similar studies using the *Composite Performance Index* method, where in this study there is a range or limit of accessibility analysis in units of 1000 m, 3000 m, and 5000 m distance. Whereas in other studies, special calculations are carried out by comparing the distance of alternative locations with all supporting locations without any distance limitations in the research location area or in one city/district area [3]. This can be interpreted that the Composite Performance Index method can be used in accordance with the respective ways of analysis in each study: [15].

4. Conclusion

Based on the results of the analysis of determining the location point of the goods terminal that has been carried out, it is concluded that in determining the location point of the goods terminal must pay attention to several criteria in accordance with the provisions, namely the criteria for road section performance, accessibility criteria, environmental sustainability criteria, and initial investment cost criteria. The results of the final calculation of the Composite Performance Index to determine the location point of the Banyuwangi Regency goods terminal show that alternative location 1 is the recommended location and gets the highest value of 192.77.

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