

Location Analysis of Freight Distribution Terminal of Jakarta City, Indonesia

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Abstract: Currently Jakarta has two freight terminals, namely Pulo Gebang and Tanah Merdeka. But, both terminals are just functioned for parking and have not been utilized properly yet, e.g. for consolidation. Goods consolidation, which is usually performed in distribution terminal, may reduce number of freight flow within the city. This paper is aimed to determine the best location of distribution terminal in Jakarta among those two terminals and two additional alternative sites, namely Lodan and Rawa Buaya. It is initialized by the identification of important factors that affect the location selection. It is carried out by Likert analysis through the questionnaires distributed to logistics firms. The best location is determined by applying Overlay Analysis using ArcGIS 9.2. Four grid maps are produced to represent the accessibility, cost, time, and environment factors as the important factors of location. The result shows that the ranking from the best is; Lodan, Tanah Merdeka, Pulo Gebang, and Rawa Buaya.

Keywords: Best location; consolidation; freight distribution terminals.

Introduction

Goods consolidation is an effort to reduce operational vehicles by carrying the same goods by combining some commodities in the same destination or near one to others [1]. Jakarta as the capital city of Indonesia has a great role in Indonesia economics activity and is one of important nodes of national economics corridor. Freight movements exist not only due to the internal economic activities of the city, but also due to the intercity freight movements. The intercity freight movements have increased the burden of city freight movements. Meanwhile, freight traffic in Jakarta now is increasing rapidly. In order to accommodate the freight activities, government of Special Capital Region of Jakarta developed two freight terminals, namely Pulo Gebang Terminal and Tanah Merdeka Terminal. However, both terminals have not been functioned properly as freight terminals; they are just being utilized as parking lots for trucks. Likely, due to their strategic location, both terminals are very potential to serve as consolidation terminals, besides two other sites, namely Rawa Buaya and Lodan.

Rawa Buaya was a bus terminal and currently utilized as bus parking lot, and Lodan is a container yard and train garage. The aim of this paper is to determine the best location of freight distribution terminal in Jakarta among those four site alternatives.

Freight Terminal and Distribution Center

Each country has its own definition on distribution center (DC), depends on the approach, policy, and factual conditions (geographic, climate, and typology). Definition and understanding of DCs related to the use of freight terminals. Browne. et al [2] definitions of DC is a logistic facility located in strategic area, to serve city center, the whole city, or specific location; with goods consolidations. Lewis et al. [1], defined goods consolidations as the way of reducing operational vehicles with the same commodity carried, and combining those similar commodities at the same direction or destinations. Furthermore, those previous definitions are further elaborated in association with the goods consolidation concept. It defines DC as a center for goods distribution, located near the city center, shopping center, or construction site, where goods are consolidated based on the same destinations. From those definitions it is shown that there is similar meaning between distribution center and consolidation center. Both terminologies, i.e. distribution center and consolidation center focus on the issue of location of the terminal. However, Lewis et al. [1] emphasized their definition on the consolidation function of terminal. Marinov [3] added explanation for Freight Distribution Center as the activity center for fulfill market's demand in pickup-to-distribute on specified connectivity.

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Definition of distribution center in this paper refer to Munuzuri [4], it explain how the freight terminal's function can be optimize to Distribution Center by adding some activity for basic function of Freight Terminal. Munuzuri [4] named freight terminal as the city terminal. In order to prevent the goods movement problems, freight terminal can be related to public infrastructure management. Public infrastructure management can be manage by two approaches, first one is to build an infrastructure physically; or second is adapting the existing infrastructure to serve inner city's logistic activities.

The success or failure of private and public sector facilities depends in part on the locations chosen for those facilities [5]. Location decisions arise in a variety of public and private sector problems. Government needs to determine locations for bases for emergency highway patrol vehicles, location of fire stations, and ambulances. Private company must locate offices, plants, distribution centers, and retail outlets.

Some factors should be taken into account to make decision on location, and they depend on the type of facility. In choosing the best location for housing, the important factors to be considered are convenience or accessibility, environment or exposure, and protection from externalities [6]. The most influencing factors in developing shop house business from the developers' point of view is financial aspect, market, location, and physical aspects, while the most influencing factors from the consumers' point of view are price and product factors [7].

In order to determine the best location of freight distribution terminal, firstly we have to define factors that affect the location selection. Synthesis of location factors of freight distribution terminal discussed in the previous studies is summarized in Table 1.

Method

The best location of freight distribution terminal is determined through two steps of analysis, namely the determination of the important factors that affect the location selection, and the analysis to find ranking of the alternative sites.

Determination of location factors is carried out through the qualitative approach, by conducting questioners to the current freight terminals users (i.e. Tanah Merdeka Terminal and Pulo Gebang Terminal) in order to analyze their perspective on the importance of the factors in term of location selection. The analysis makes use of Likert scale, a psychometric scale to measure respondent's opinion about any issue [8].

Table 1. Location Factors of Freight Distribution Terminal

No	Group of Factor	Location Factor
1	Cost	Distribution services cost [8,9,10] Cargo transfer cost [8,9,10] Construction and transport cost [8,9,10] Land and maintenance cost [8,9] Land price [8,9]
2	Accessibility	Congestion [8,9] Distance between terminal and market [8,10] Delivery speed [8] Distance between terminal and supplier [8,10] Access and circulation in port, market, and intermodal terminal [9,10] Density and capacity of road around the terminal [10] Arterial and toll road services [10] Local road capacity [10,11] Located within freight network [11] Access from terminal gate to the road[11] Integrated mode [9,10,4]
3	Time	Delivery time [8] Travel time [8,9,10] Congestion time [8,9,10] Transfer time [8] Loading-unloading time [8] Frequency of truck in-out terminal [8,10]
4	Reliability	Reliability of services [8] Traffic condition [8] Physical condition of cargo [8]
5	Land Use	Land use complies with the city plan [9,10,11] Land area is minimum 3 ha for Java Island and 2 ha for out of Java Island[11] Near to freight generator and marketplace [4,10,11] Land availability [10,11] Topography condition of terminal [9,10]
6	Policy	Support goods consolidation and intermodal facilities development through good container facility [9,10] No truck restriction zone within 24-hour terminal operation time [10] Access for truck to enter the main road[10] Comply with the local tax policy [10]
7	Environment	Sufficiency of water supply and drainage [9,10] Man power availability [10] Environmental sustainability [9,11] Planning and providing freight network with environmental concern (near settlement and commuter route) [11]
8	Socio-Economics Impact	Economics potential of terminal [8,9,10] Truck flows on the road [8]
9	Safety/ Security	Traffic and cargo safety [8,10] Road Security [8,10]

Respondents are chosen by purposive sampling methods due to the limited number of freight terminal users. Twenty respondents are chosen representing several national logistics firms in Greater Jakarta.

The firms included in the survey are as follows:

1. Logistics firm that has experiences of using distribution center, or has intention to use it.
2. Logistics firm that deals with consumer goods (retailer needs) and industrial goods. It includes all types of goods except liquid, hazardous, and raw foods materials.
3. Logistics firm whose scope of services is in national level.

All the location factors identified in the literature reviews (see Table 1) are put in the questionnaire, and the respondents are asked to give their opinion on those factors using 5 scale of Likert as follows: 1 for no influence; 2 for fair influence; 3 for influence; 4 for very influence; and 5 for extreme influence. The final weight of each factor is calculated using Equation 1 as follows [12]:

$$W = \frac{\sum S(T P_s)}{N} \quad (1)$$

where:

W = Weight of each factor

T = Number of respondent choosing scale- s

P_s = Likert scale- s

N = Number of respondent

S = Number of Likert Scale

The number of factors considered in the questionnaire is 42. In order to simplify further analysis, the factors are reduced by classifying them into two classes, namely primary factors and supporting factors. Only the primary ones are taken into account in the further analysis. Both classes are distinguished using their weight resulted from Likert analysis. Interval range of the weight of both classes is determined by Equation 2 as follows:

$$r = \frac{(X-Y)}{n} \quad (2)$$

in which r is the range of interval of a class, n is the number of class, X is the maximum weight, and Y is the minimum weight.

Furthermore, the determination of primary location factors is followed by the analysis to rank the four alternative sites. It is carried out by applying weighted overlay analysis, a method of spatial analysis whose ability is to combine several different Geographic Information System (GIS) layers in order to enable complex queries to be performed as its purpose. Here, its purpose is to find the best location, as well as the ranking of the alternative sites of the freight distribution center. The analysis is supported by ArcGIS software [13].

Overlay analysis constitutes two types of map, namely basic map and grid map. Basic map is a raster map that represents values of variable associated to the location factor of each spatial unit

on the map. The basic map is generated using the values of variable which come from primary survey or secondary data published by the associated authority. For example, the basic map of “distribution service cost” indicates the cost to serve goods distribution in all spatial units existed on the map. The data comes from the primary survey. Since the spatial unit used in the overlay analysis is unit of district (Kecamatan), hence the data of district where the alternative site is located will represent data of the alternative site of terminal. In order to synchronize various units of the basic maps, all the data on each basic map are classified into some levels, and the ArcGIS generates certain value to represent such levels in further analysis. Hence, each spatial unit in study area has its own level of factor that associated to the basic map it represents. The number of level of each basic map is defined by arbitrary judgement, which depends on the range of value of the variable. As the range is quite big, it is better to set more levels to find more precision on further analysis. For example, the authors use three levels of data, i.e. low, medium, and high for basic map of ‘Cargo Transfer Cost’.

Furthermore, the grid map is formed by overlaying some basic maps into one map based on certain theme. Themes for grid maps are taken from group of location factors stated in column 2 of Table 1. Hence, there exists grid map of Cost, Accessibility, Time, Environment, and Safety and Security. The overlaying of basic maps is plausible due to the substitution of the original ‘unit’ of basic map into ‘level’ as described above. For the factors that positively support the success of terminal operation (e.g. ‘access from terminal gate to the road’), the higher the level on basic map the more suitable the site would be, and vice versa (e.g. ‘travel time’ factor)- Hence, in the overlay of basic maps, the positive factors are indicated by positive value, whereas the negative factors are indicated by negative value.

Lastly, all grid maps are superimposed to form the final map by applying the Likert weights that correspond to each grid maps. The final map shows the suitability of each spatial unit to be a distribution terminal. In this case, suitability is classified into three levels, namely low, fair, and high. Similar to the basic map and grid map, ArcGIS generates certain value, i.e. suitability weight, to each level of final map. In order to find the final result of the overlay analysis, ArcGIS measures the proportion of area corresponds to each level. Afterward, the proportion of area is multiplied by the associated mid value of suitability weight to find suitability value, and then the suitability values of the three levels are summed up to find the total suitability of each alternative site. The higher the suitability value, the better the site to be chosen as distribution terminal.

Result and Discussion

Analysis of Location Factors of Freight Distribution Terminal

The result of Likert analysis that generates the location factors with their weight is shown in Table 2.

Table 2. Result of Likert Analysis

No	Location Factor	Weight
1	Distribution services cost	10.0
2	Cargo transfer cost	15.4
3	Construction and transport cost	6.4
4	Land and maintenance cost	6.2
5	Land price	6.8
6	Congestion	11.6
7	Distance between terminal and market	14.6
8	Delivery speed	7.6
9	Distance between terminal and supplier	12.0
10	Access and circulation in port, market and intermodal terminal	13.4
11	Density and capacity of road around the terminal	12.4
12	Arterial and toll road services	16.8
13	Local road capacity	14.8
14	Located within freight network	16.6
15	Access from terminal gate to the road	15.4
16	Integrated mode	11.4
17	Delivery time	8.0
18	Travel time	11.8
19	Congestion time	8.0
20	Transfer time	7.6
21	Loading-unloading time	11.6
22	Frequency of truck in-out terminal	12.0
23	Reliability of services	9.8
24	Traffic condition	7.6
25	Physical condition of cargo	7.2
26	Land use complies with the city plan	8.0
27	Land area is minimum 3 ha for Java Island and 2 ha for out of Java Island	6.6
28	Near to freight generator and marketplace	11.6
29	Land availability	6.4
30	Topography condition of terminal	8.6
31	Support goods consolidation and intermodal facilities development through good container facility	10.2
32	No truck restriction zone within 24-hour terminal operation time	11.6
33	Access for truck to enter the main road	7.6
34	Comply with the local tax policy	6.6
35	Sufficiency of water supply and drainage	11.6
36	Man power availability	6.2
37	Environmental sustainability	7.0
38	Planning and providing freight network with environmental concern (near settlement and commuter route)	14.2
39	Economics potential of terminal	6.6
40	Truck flows on the road	8.8
41	Traffic and cargo safety	11.4
42	Road Security	10.8
Total index of variable		428.8
Average index of variable		10.2

Based on the highest weighted location factor (i.e. 16.8) and the lowest weighted location factor (i.e. 6.2), the interval (r) for each class of factor is 5.3, giving the supporting factors as all location factors with weighted Likert scale below 11.5, and the primary factors above 11.5 (>11.5). The supporting

factors has 24 factors, and the primary factors has 17 factors. The analysis only considers the primary factors (Table 3). All factors that represent the safety and security are included in the supporting factors; hence, those factors are discarded in further analysis.

Overlay Analysis of the Alternative Sites

In the establishment of the basic maps of all factors, due to the complexity of data acquiring of the basic map, the authors use same basic map to represent several factors whose spatial characteristics are slightly similar. As the most representative factor, the biggest weight of such factors is chosen to designate the weight of such basic map. For example, “Near to freight generator and marketplace” and “Distance between terminal and market” factor are represented by one basic map, i.e. “Map of distance between terminal and market”, by designating the weight of 14.6 for such map (see Table 3). Accordingly, the classification of group of factor in the overlay analysis is slightly changed to justify the availability of basic map. Afterward, based on the Likert analysis, there are only four grid maps that should be considered in the GIS analysis; those are Cost, Accessibility, Time, and Environment.

The factors and their groups of factor, as well as the associated basic map and grid map that are used in the overlay analysis are described in Table 3, and the mapping of location factors and the associated maps is shown in Figure 1. The basic maps as well as grid

maps are shown in Figure 2a~2j and Figure 3a~3d, respectively. The levels of each basic map as well as the ones of grid map are indicated in the legend of the map, and to ease the interpretation of the map, each level of the all maps is represented by certain color. Furthermore, the final map that shows the overlay analysis result is shown in Figure 4.

The total matching value of each site is summarized in Table 4. Based on the total value of suitability of all the alternative sites, the ranking of the sites (from the best one) is as follows: 1. Lodan; 2. Tanah Merdeka; 3. Pulo Gebang, and 4. Rawa Buaya.

As the location whose total value of suitability is the highest, Lodan Terminal becomes the most suitable location for the distribution terminal. In fact, Lodan is located in the middle of east-west Jakarta highway corridor so travel time to reach this site from all directions is relatively less. Lodan is also located in the center of industrial sites and it has good access to toll road and arterial road, as well as Tanjung Priok Port. It is indicated by the dominance of quite high level of suitability of the Grid Map of Cost and Accessibility at Lodan area.

Table 3. Factor, Sub Factor and Map on the Overlay Analysis

Group of Factor	Factor	Weight of Factor	Basic Map	Weight of Basic Map	Grid Map
Cost	Cargo transfer cost	15.4	Map of Cargo Transfer Cost	15.4	Map of Cost Factor
Access	Congestion	11.6	Map of congestion	14.2	Map of Accessibility Factor
	Frequency of truck in-out terminal	12.0			
	No truck restriction zone within 24-hour terminal operation time	11.6			
	Density and capacity of road around the terminal	12.4	Map of distance between terminal and market	14.6	
	Planning and providing freight network with environmental concern (near settlement and commuter route)	14.2			
	Distance between terminal and market	14.6			
	Near to freight generator and marketplace	11.6			
	Distance between terminal and supplier	12.0	Map of distance between terminal and supplier	12.0	
	Access and circulation in port, market and intermodal terminal	13.4	Map of access and circulation in port and intermodal terminal	16.6	
	Located within freight network	16.6	Map of arterial and toll road level of service	16.8	
	Arterial and toll road services	16.8			
Local road capacity	14.8				
Access from terminal gate to the road	15.4	Map of access from terminal gate to the road	15.4		
Time	Travel time	11.8	Map of travel time	11.8	Map of Time Factor
	Loading-unloading time	11.6	Map of loading-unloading time	11.6	
Environment	Sufficiency of water supply and drainage	11.6	Map of sufficiency of water supply and drainage	11.6	Map of Environment Factor

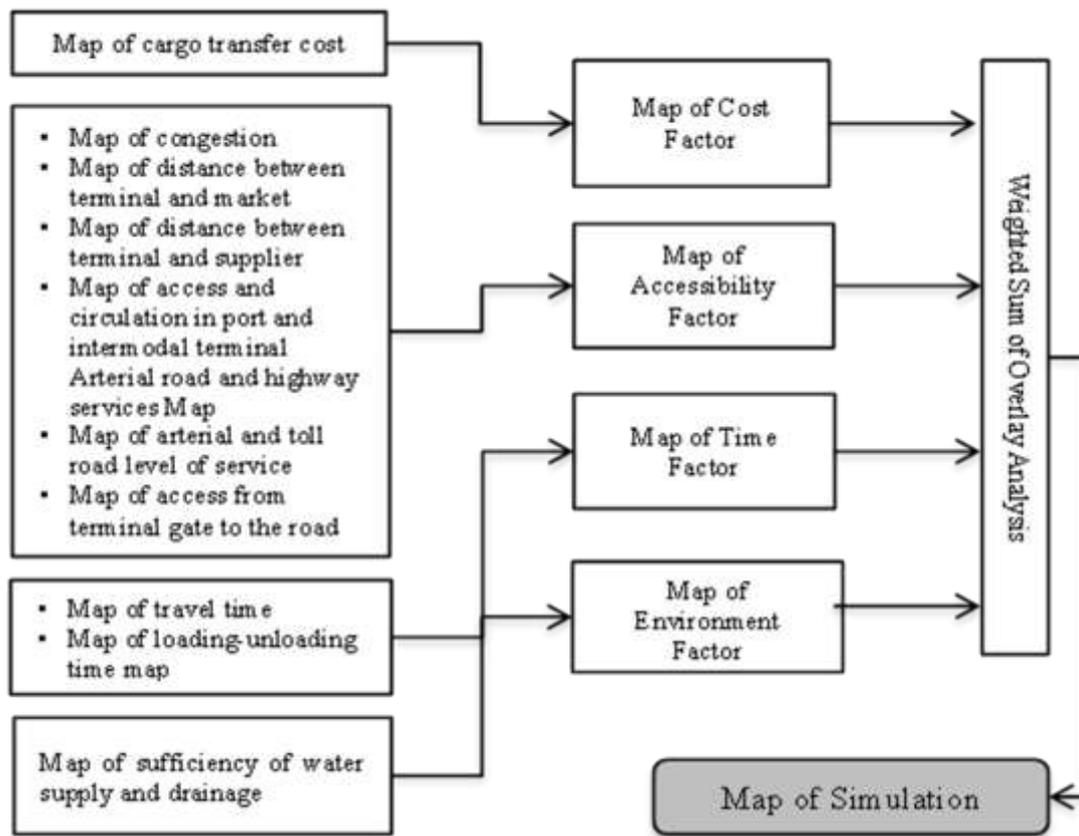


Figure 1. Mapping of the Overlay Analysis



Figure 2a. Basic Map of Cargo Transfer Cost

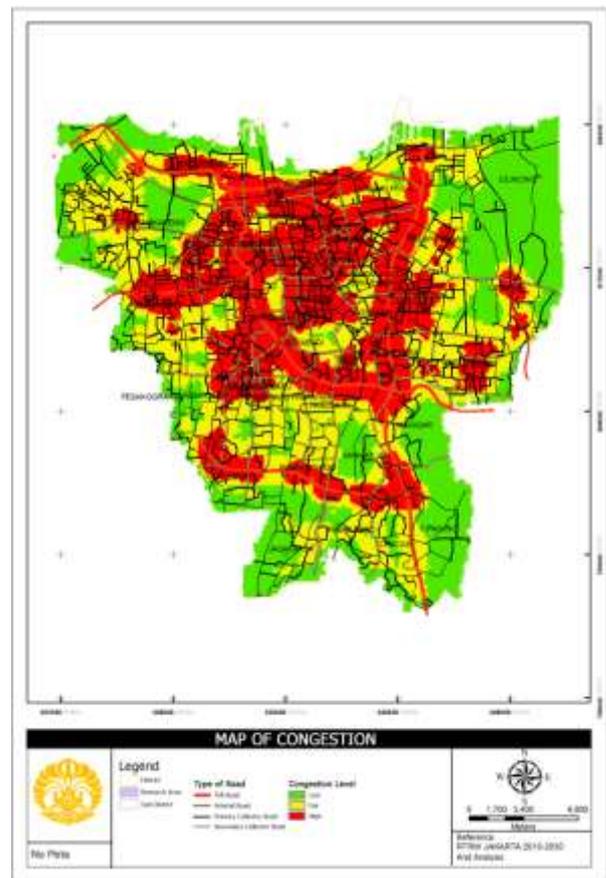


Figure 2b. Basic Map of Congestion

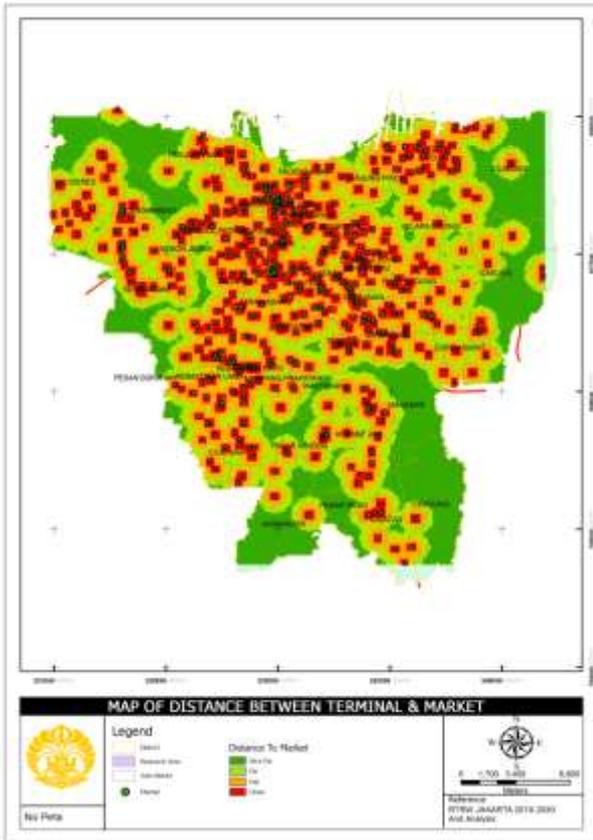


Figure 2c. Basic Map of Distance between Terminal and Market

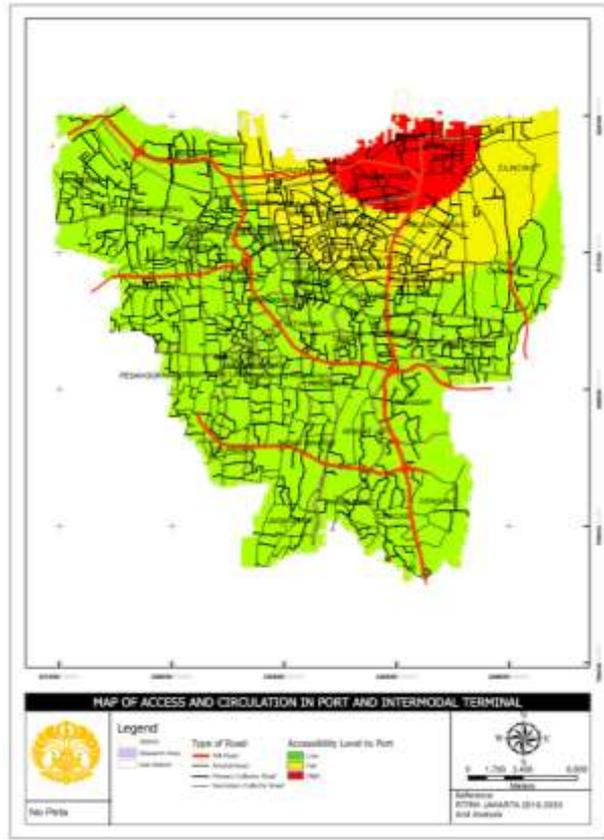


Figure 2.e Basic Map of Access and Circulation in Port and Intermodal Terminal

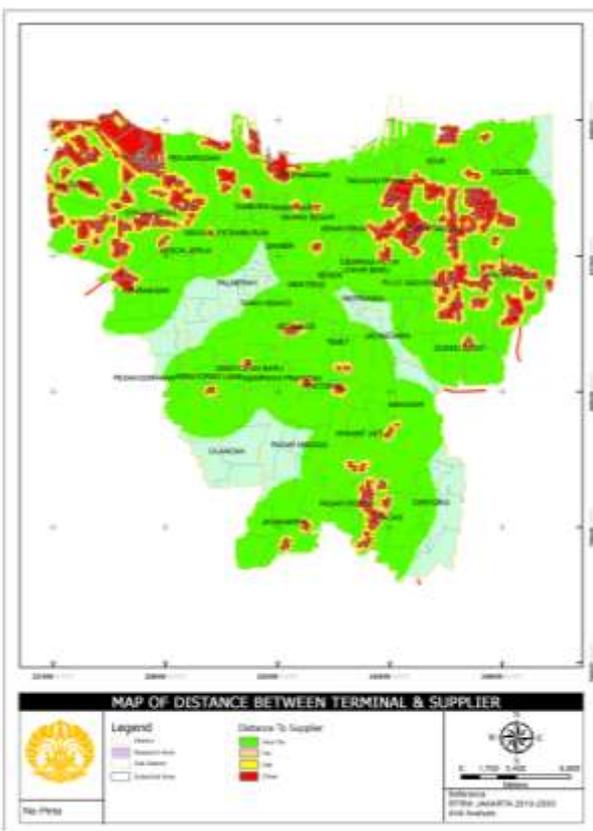


Figure 2d. Basic Map of Distance between Terminal and Supplier

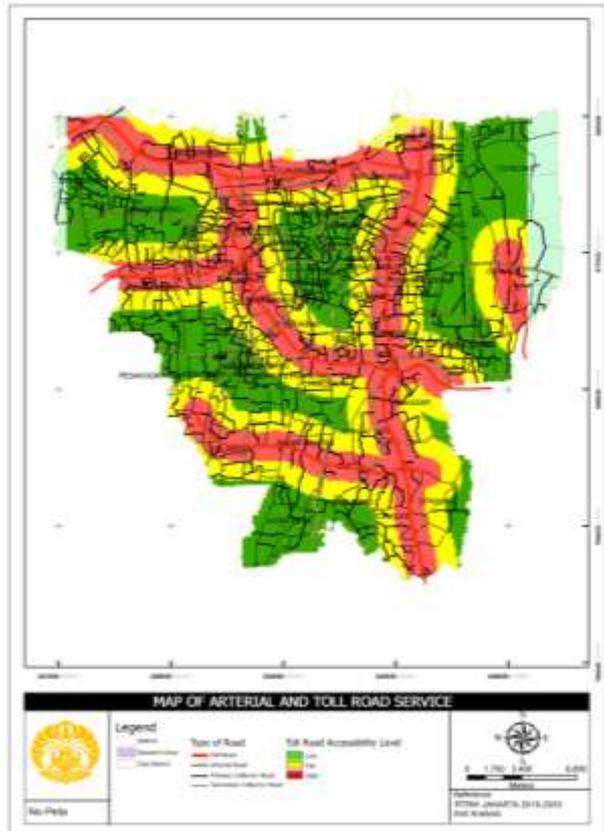


Figure 2.f Basic Map of Arterial and Toll Road Service

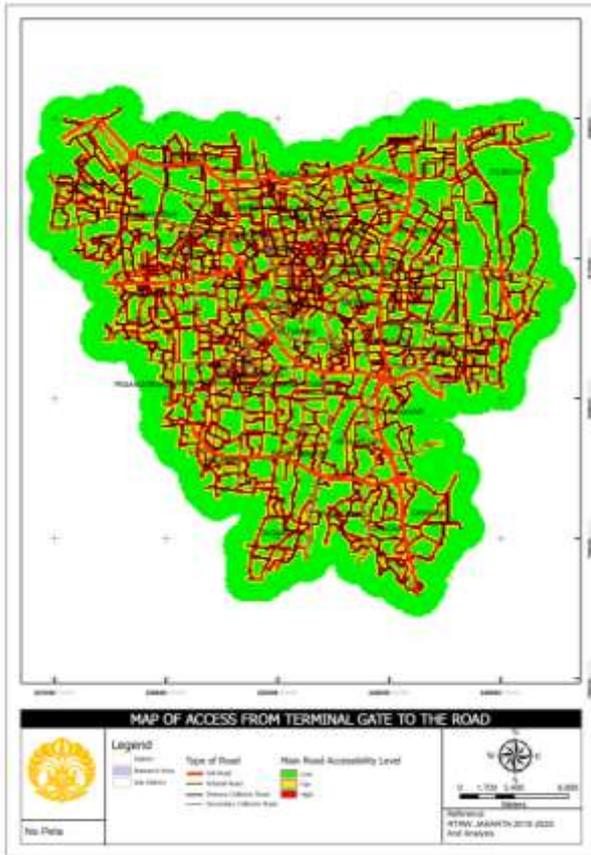


Figure 2.g Basic Map of Access from Terminal Gate to the Road



Figure 2.i Basic Map of Loading-Unloading Time



Figure 2.h Basic Map of Travel Time

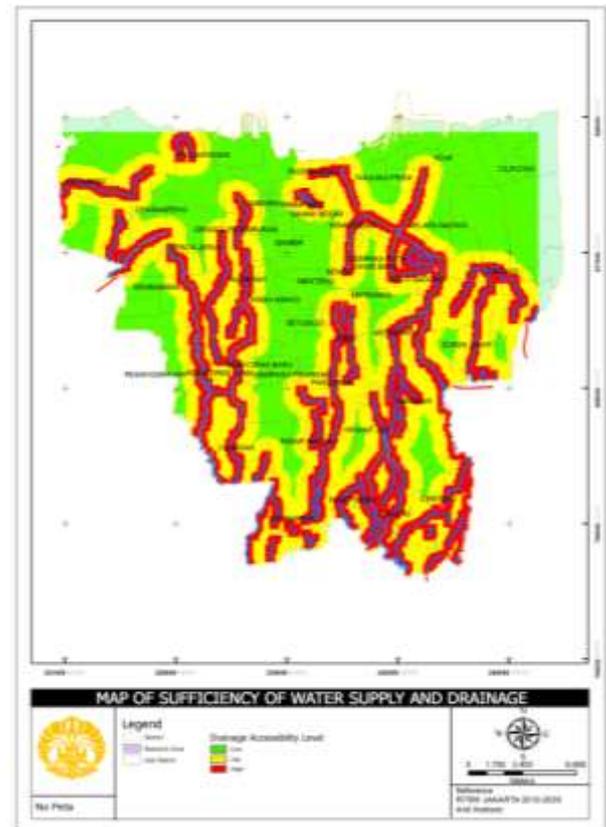


Figure 2.j Basic Map of Sufficiency of Water Supply and Drainage

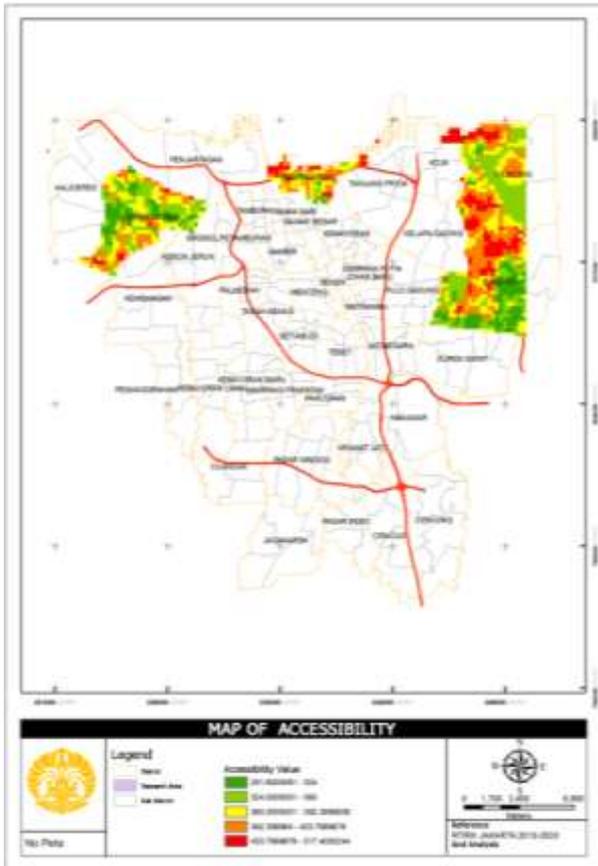


Figure 3a. Grid Map of Accessibility



Figure 3c. Grid Map of Cost

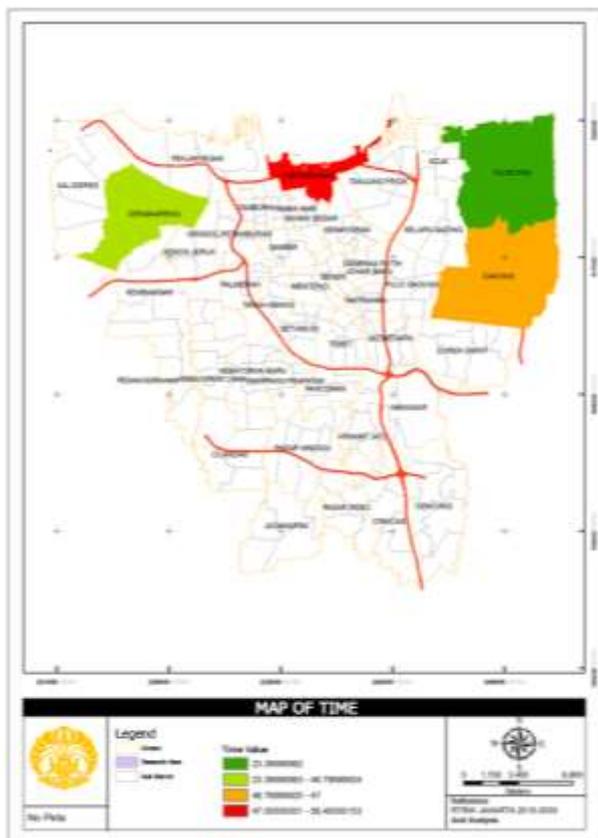


Figure 3b. Grid Map of Time

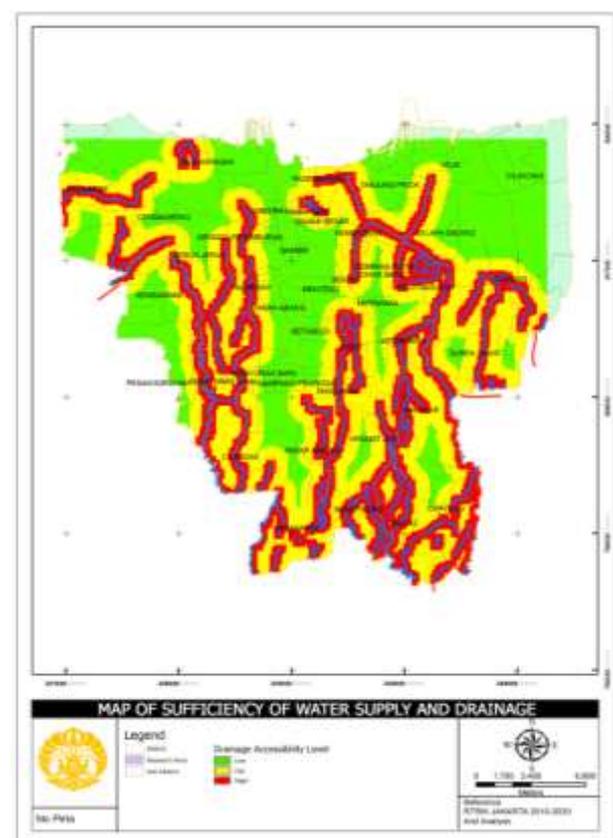


Figure 3d. Grid Map of Environment

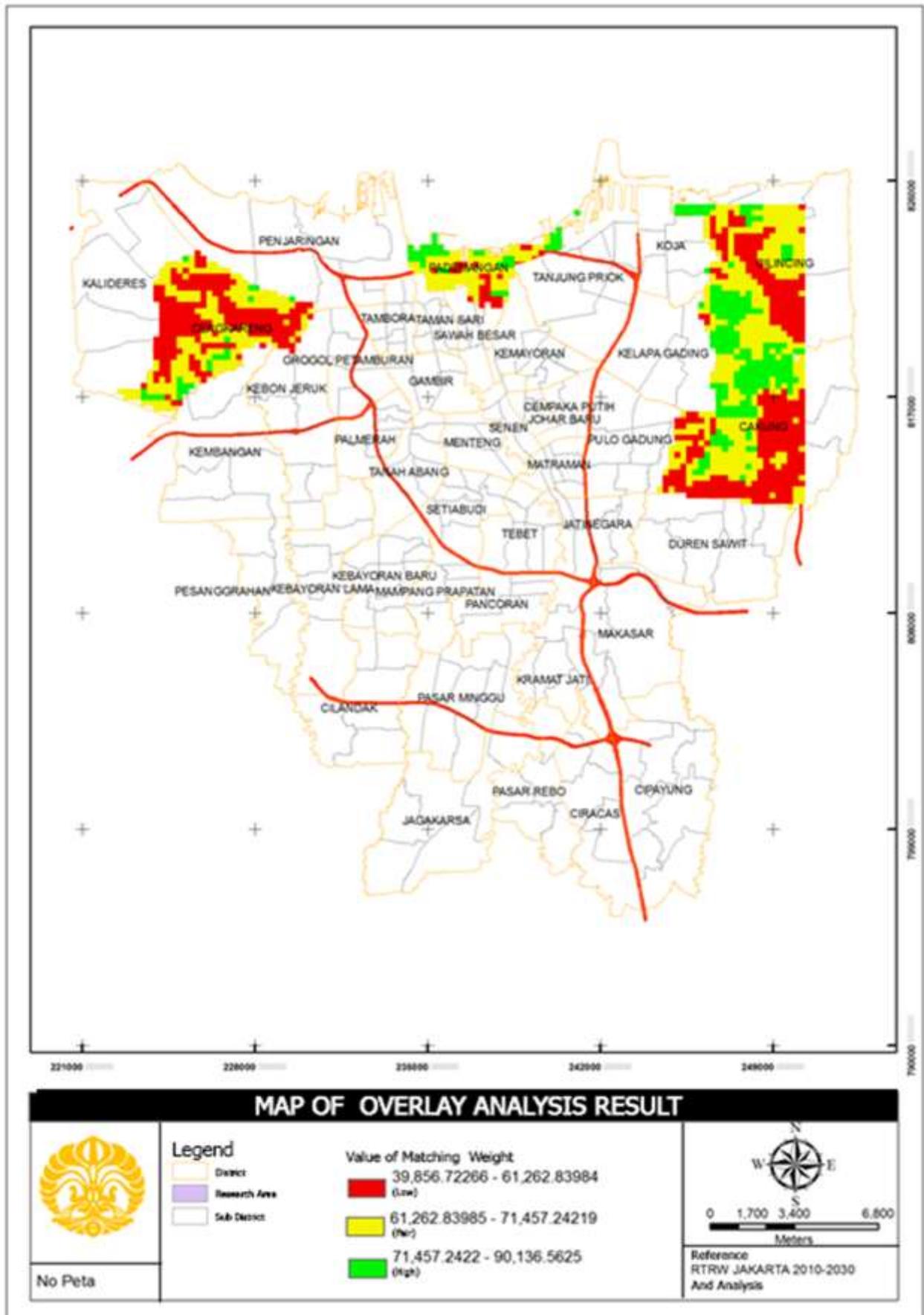


Figure 4. Final Map of Overlay Analysis

Table 4. Suitability of the Alternative Sites

No	Alternative Site	Level of Suitability	Proportion of area	Mid Value of Suitability Weight	Suitability Value	Total Suitability Value
1	Pulo gebang	Low (1)	0.42	50	21.19	61.80
		Fair (2)	0.36	65	23.76	
		High (3)	0.211	80	16.86	
2	Rawa Buaya	Low (1)	0.49	50	24.71	58.36
		Fair (2)	0.45	65	29.54	
		High (3)	0.051	80	4.11	
3	Tanah Merdeka	Low (1)	0.29	50	14.71	63.79
		Fair (2)	0.49	65	31.97	
		High (3)	0.21	80	17.11	
4	Lodan	Low (1)	0.14	50	6.85	66.47
		Fair (2)	0.63	65	40.82	
		High (3)	0.23	80	18.79	

Conclusion

The overlay analysis using ArcGIS has been applied to determine the best location of freight distribution terminal in Jakarta. The result shows that the four alternative sites are ranked as follows (from the best one): Lodan, Tanah Merdeka, Pulo Gebang, and Rawa Buaya. The ranking is determined based on cost factor (i.e. cargo transfer cost), accessibility factor (i.e. congestion, distance between terminal and market, distance between terminal and supplier, access and circulation in port and intermodal terminal, arterial and toll road level of service, access from terminal gate to the road), time factor (i.e. travel time and loading-unloading time), and environment factor (i.e. sufficiency of water supply and drainage). Those factors are derived from Likert Analysis on survey directed to freight terminals users. In order to refine this study result, further analysis may be required by taking into account the disused location factors due to the simplification done in this study.

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