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The Development of Decision-support Model for the New Oil Station Based of Geographical Information System

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Abstract: The purpose of this research is to find out the new location of oil station. The measurement is conducted by looking at the level of demand and supply at the new location. The level of demand measured by surrounding activity within the radius of 500 meters from the new location of the oil station. The activity level is measured by considering the number of trading centers, financial centers and education centers within the radius of 500 meters from the new location. The supply measurement is done by measuring the level of competitionsata particular oil station location. The level of supply is measured by counting the number of oil stations within the radius of 500 meters. The research methodology in order to measure the location feasibility is using index model. First, it is evaluating the level of relative important in each criteria to other criteria. Second, the data is standardized on each criteria. Finally, it is counting index value by adding up the multiplication among other criteria with each criteria standard value. The highest index value is 5 meaning that is highly feasible while the lowest value is 1 meaning that it is the least feasible.

Key words: oil station; demand supply; index model; GIS
JEL code: M21

1. Introduction

The issuance of business license for foreign oil companies Shell and Petronas cause the national oil company, PERTAMINA (Indonesia Oil Company), to be more cautious in handling oil stations under their management. If the investor of oil station finds that managing PERTAMINA's oil station is become less profitable, then they will tends to think about moving on another company, in this case, Shell or Petronas, should those companies are promising a better fortune. It needs to be considered seriously because as new comers, they will set a strategy of giving a higher incentive rather than PERTAMINA. The investor of these foreign companies then, in the next stage, will give a better incentive to their customers. It might be in the form of free gifts, price cuts or better services, and a cozy atmosphere in the oil station complete with convenient store as they had had in Malaysia, their country of origin. Should this scenario is executed then it will be a threat to be reckon with by PERTAMINA as one of our national asset. This paper therefore will have its focused on how to determine a more sustainable location for the new oil station, so it can be beneficial for all parties: PERTAMINA, oil station investor and for the consumers, and will be able to compete with those foreign companies which have had the business license in Indonesia.

People of Indonesia have an interest in the existence of oil station in order to support their need of

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transportation, either individual or public transportation. However, as we know recently that the oil station is now over-growing, causing the lack of profit for some of oil station. Society, as a consumer, had suffered for about 43 billion rupiah lost per year due to the fraud committed by oil station (Pikiran Rakyat, July 26th 2006), in form of dose reduction by using several kind of technology. One of the contributing factor that caused this fraud is location factor, where if the distance between one oil station with the other is too close, then it will lead to decreased turnover on each oil station. In Surabaya, for instance, there are two oil stations that are separated by distance which is less than 500 meter (Jawa Pos, December 4th 2007). This paper is strive to design a decision-support model for the new oil station based on Geographic Information System (GIS) by considering economic and geographic factor so that it is possible for the new oil station to avoid this decreased turnover problem. This economic factor is important because it's concerned of a long-time prospect, where theoretically, once a business is established then it is expected to have a long life cycle. Meanwhile, geographic factor is expected to support this life cycle to stay longer considering the ease of location accessibility and comfort level of the business. The location selection is a very critical process in every company as this decision determines the sustainability of the company itself. The fault on choosing a company location cannot be shortly changed because it involving a huge investment and had an impact on the whole company strategies (Zainab et al., 1996). With the result of this paper it is expected that the fault of location-choosing is not to be happen again.

The main problem on this paper is how to design Decision Support for the new oil station based of Geographical Information System.

2. Literature Study

Based on PERTAMINA's early survey result, the establishment of new oil station is still paying less attention in location factor, proved by the existing of two oil station that separated by the distance less than 500 meters. Therefore, by using geographic information technology, a circumstance in particular radius is able to be viewed visually. Those circumstances may include education center, trade center, and oil station nearby the new location planning, street direction and traffic condition. The significance of location and the capability of GIS in measuring and analyze appropriateness of a location will be discussed as follow:

2.1 Location

Location is a critical factor that determine the whether one company will be success or not (Bolen, 1988). The location selection for a company is an effort in order to get customers. Location is capable to determine appropriateness and ease of customer to get the products. Location selection is closely related with way of attracting customers into the company. A correct way of selecting location is therefore become very important, that is by searching a spot in the area of which the best market prospect after indentifying some particular region (Hasty & Reardon, 1997).

For common people, the location selection is turns to be something easy and instinctively, that is based only on Gut Feeling (Bhushan & Tayal, 1979; Berman & Evans, 1992). But for the company, this matter is highly important. It is because the demand and bargain factor for the product is closely related with location selection.Many of the researchers assert the significance of location in determining company success, they are Hasty and Reardon (1997), Birkin et al. (1996), and Berry (1976). Environment plays an important role in determining the success of a good location searching. This circumstance is including the sector of target customers. If the location is set within the target customer area, then the maximal profit will be achieved (Berman & Evans, 1992).

Location searching is a process in searching an appropriate location for the company. It is performed under the circumstances to develop a company to new region. It emphasized physical condition of the location and environmental to create the product's attracting and repellent factors. The position of location here needs to be seen as an inseparable entity with the surrounding factors. Bolen (1988) stated that every location in the earth had its analyzable advantages and disadvantages. These factors can be classified into 2 physical condition, they are real physical and analysis physical. Real physical is a visible condition in related area such as land condition, the width, and the distance from the highway company has criteria to see this real physical condition. Analysis physical, in the other hand, is physical condition obtained from physical analysis such as population analysis, neighborhood factor, and competitor analysis. Right after the entire strength and weakness are collected was the decision is to be made.

Location appraisal is a process of making a valuation against a location to choose the best one. Sorting of location searching will normally provide many locations to choose from. So to make a choice from several locations it is necessary to make assessment of each location (Ghosh, 1994). Location appraisal then will be used as a standard to obtain strong evidence in order to make a better choice. Location appraisal here is a process to make an assessment about a new locations obtained from location selection. This Assessment of the desired location involves several processes that is used in the current assessment is by using the Index model. Those locations will be evaluated with several established criteria.

2.2 GIS

Geographic information is an information which describe the real world from three aspects; first is the geographical position (space dimension) which explain the location of particular phenomenon and its connection with another; second is attribute (theme dimension) which explain the criteria of some space and not the phenomenon space itself; third is time information (time dimension) which explain the behavior or characteristic of a phenomenon based on the time (Ruslan & Noresah, 1998). Geographical data usually presented in form of a map and represented by dots, lines or regions as shown in Figure 1.

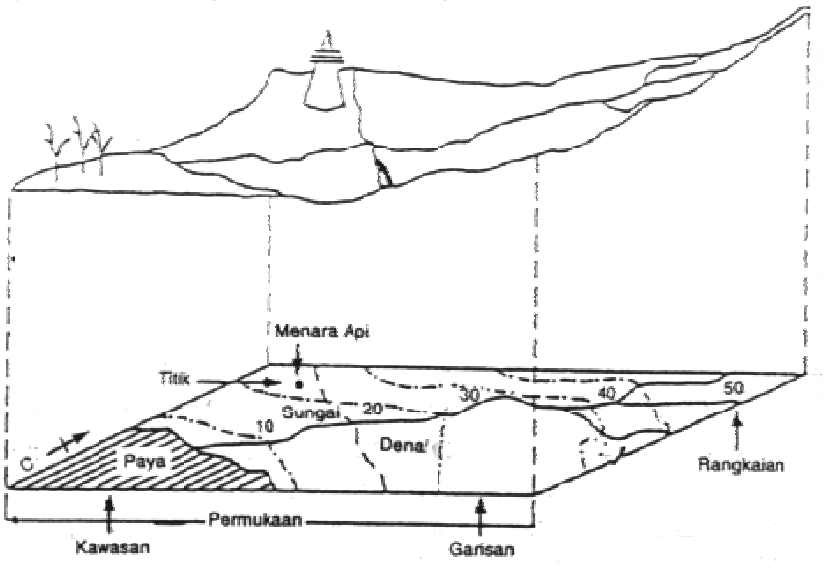

Figure 1 Geographical Data Representation

The dots is used to mark or represent the criteria associated with one single location which is too small to be presented as lines or regions, for instance telephone pole, ATM, etc. Lines are used to represent linear

characteristic, which theoretically had significance in length but not in width so that it cannot be represented in form of a region. And the region itself is sort of space with boundaries and is used to represent characteristic that has both significance length and width such as river, cities, land, etc. These three forms of representation can be combined to represent some more complex phenomenon like surfaces, series and networks. One advantages of this geographic data is to have a position element that is able to express either in absolute or relatively. An absolute position is a geographic coordinate system by means of longitude and latitude as shown in Figure 2.

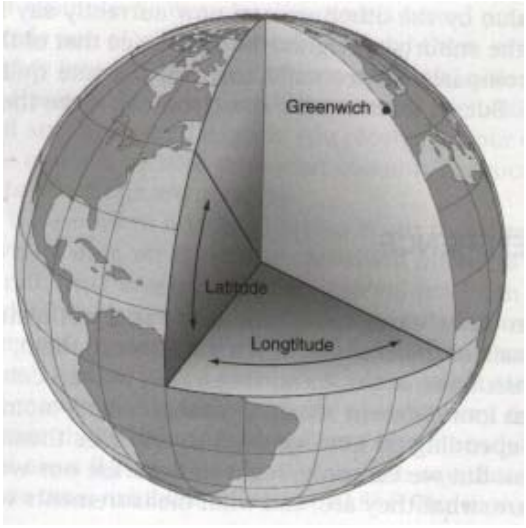

Figure 2 Absolute Position with Longitude and Latitude Coordinate

Meanwhile, a relative position is about its relationship with another phenomenon based on the concept of distance and direction. These forms of relationship are contiguity, proximity and content, which is better known as topology map information shown in Figure 3.

Figure 3 Relative Position and Topology Connection

Geographic information system (GIS) is one kind of technology that able to integrate various data and geographic information operation that is necessary to analyze space. GIS can be used for measurement, mapping, monitoring, visualization and space modeling purpose.

2.3 Result of Previous Oil station New Location Searching Model

Previous model to search new location for oil station was design by Nayan (2006) which also called as Oil Station Location Searching System in Petronas Malaysia is a decision making support application system in space. The approach used to evaluate location is market and neighborhood analysis. For market analysis, the factors used are people's purchasing power, area development and demand in the region. Meanwhile, for neighborhood analysis factor considered are location front yard, land area, number of vehicle and the distance from oil station to the highway. The method used here is to assess feasibility here is Multi Criteria Analysis (MCA) and Analytical Hierarchical Process (AHP).

3. Research Location

The research location is in Gubeng district which consist of 6 sub-district as shown in Table 1.

Table 1 List of Sub-district in the Gubeng District

No.	Name of Sub-district	Area (km^2)
1	Baratajaya	1.26
2	Pucangsewu	0.97
3	Kertajaya	1.14
4	Gubeng	0.88
5	Airlangga	1.19
6	Mojo	2.55
Total		7.99

As for the map location is given in the Figure 4.

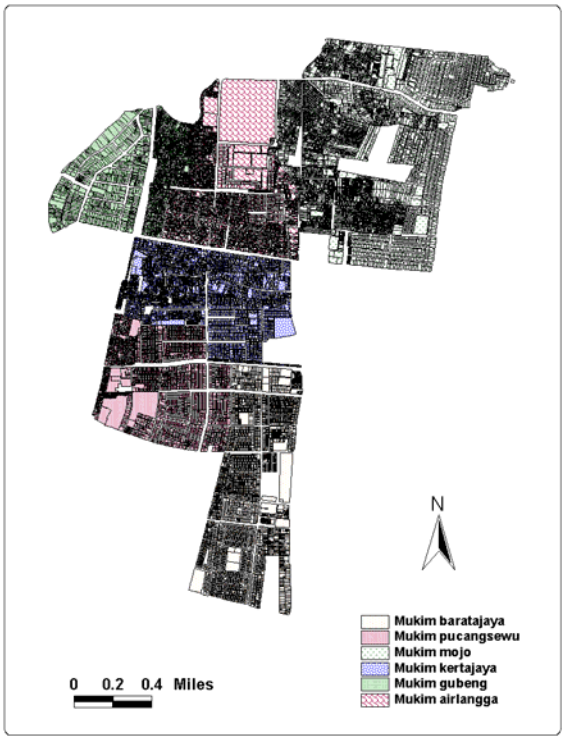

Figure 4 Gubeng District Map, Surabaya City

4. Research Method

4.1 Data Collection

Data collected is a space and non-space data in oil station new location candidates. Space data is collected through GIS while non-space data is collected through field observation.

4.2 Data Processing

After the data is tabulated, then market demand, level of competition and ease of access of the location is calculated using index model.

4.2.1 Index Model

Model is a simple representation from one phenomenon or system. Index model will count index value from every area unit that involves several criteria and weighting (Kang Tsu Chang, 2008). The formula to count index value is as follow:

$$I_i = \sum_{i=1}^{n} W_i X_i \quad (1)$$

With I_i is the index value, n is the criterion, W is the weight and X is the standard value.

Basically there are 3 steps in calculation index value:

Step 1: Evaluated relative importance of each criteria against the other criteria or weighting.

Step 2: standardize the data for each criteria

Step 3: calculating index value by sum up the multiplication result between weighting with standard value if each criteria

Visually, the example of those three steps above can be seen in Figure 5.

Index value calculation is performed using three criteria: slope, aspect and elevation as shown in Figure 1. First step is to determine weight of each criterion: W_s for Slope, W_a for aspect and W_e for elevation; the total weight for W_s, W_a and W_e is 100%. Next step is data standardization with any particular scale, for instance 1 is the lowest value and 5 is the highest through the classification process for each criterion. Third step is data aggregation (I_1, I_2, I_3) by sum up the multiplication result between each criterion weight (W_s, W_a, W_e) with standard value of each region (s_1, s_2, s_3, a_1, a_2, a_3, e_1, e_2, e_3). The minimum index value therefore will be 1, and the maximum value will be 5.

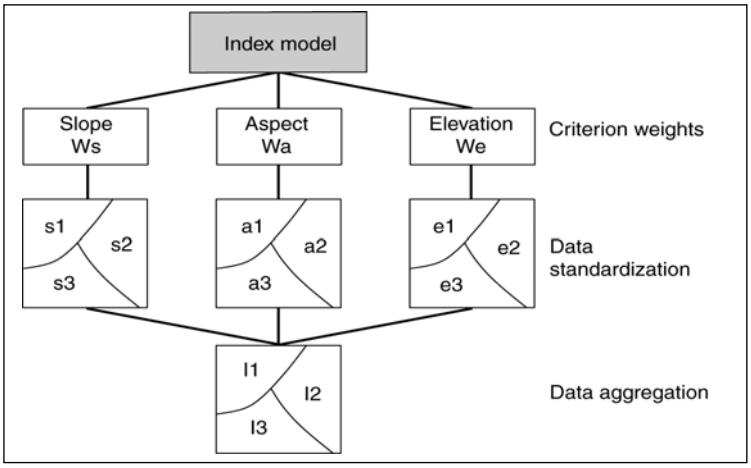

Figure 5 Index Model Calculation

4.2.2 Index Value for Feasibility of An Oil Station's New Location Candidate

Index value for oil station new location is established from market demand and competition level. If market demand is high, then feasibility value will be high to, and vice versa. If competition level is high then the feasibility will be low and vice versa. Market demand from oil station new location candidates is found with situational and activity approach around the oil station within the 500 meters radius. Based on those approaches, there are 5 criteria for demand. They are:

(1) Number of trade center within 500 meters radius

(2) Number of houses within 500 meters radius

(3) Number of education center within 500 meters radius

(4) Number of financial center within 500 meters radius

(5) Number of social center within 500 meters radius

Competition level and ease of access are found by seeing the nearest oil station and ease traffic. Based on those approaches, there are 3 criteria to determine the competition level:

(1) Number of oil station within 500 meters radius

(2) Distance to the nearest traffic light

(3) Land area

The flowchart of the methodology can be seen in Figure 6.

Based on the steps describe in model index, the first thing to do is to weight every criteria based on the level of importance, where the total of weighting is always 100%. Result from oil station owner's opinion is tabulated on Table 2.

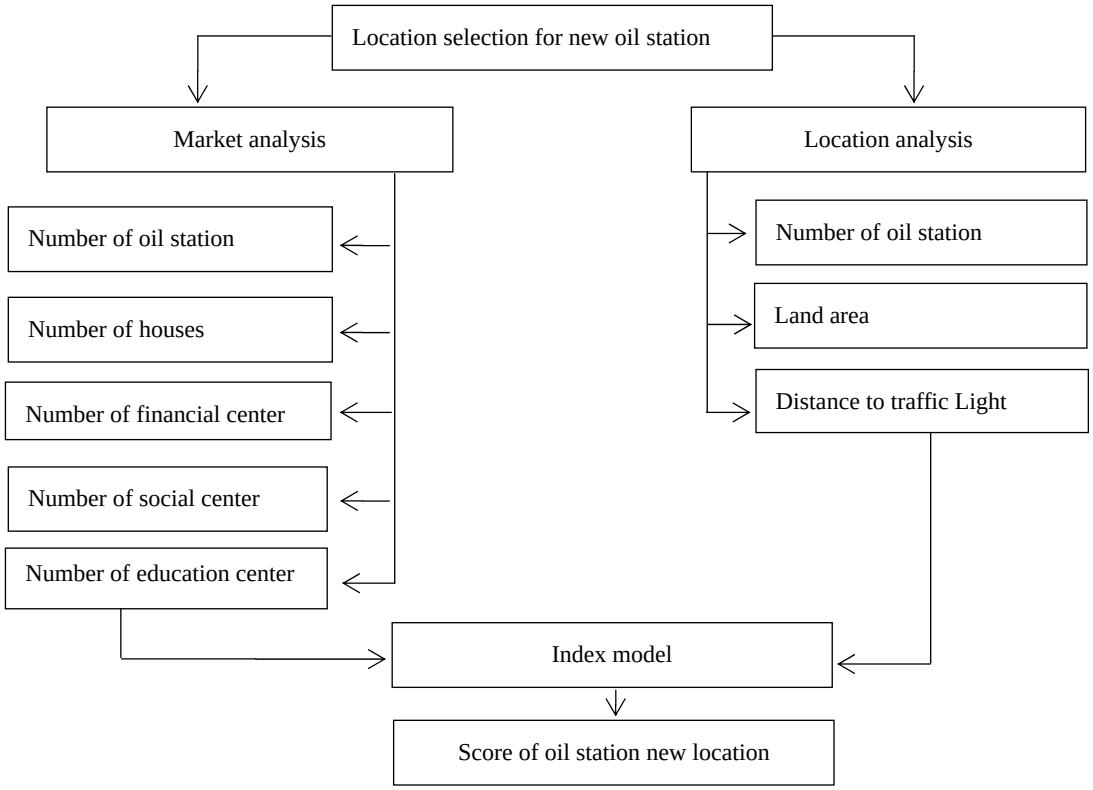

Figure 6 Methodology Flowchart

Table 2 Weighting of 8 Feasibility Criteria on Oil Station New Location

No	Criteria	Weight (%)
1	Number of oil station within 500 meter radius	19
2	oil station area	18
3	Distance to the traffic light	16
4	Number of trade center within 500 meters radius	15
5	Number of financial center within 500 meters radius	13
6	Number of education center within 500 meters radius	11
7	Number of social center within 500 meters radius	8
8	Number of houses within 500 meters radius	7
Total		100

Second step is to standardize data with the minimum value of 1 and maximal value on 5, the result is as follow:

(1) Another oil station

Number of oil station within 500 m radius	Score	Feasibility
>=4	1	Highly unfeasible
3	2	Not feasible
2	3	Fairly feasible
1	4	Feasible
0	5	Highly feasible

(2) Land area

Land Area of New oil station (m^2)	Score	Feasibility
700–1160	1	Highly unfeasible
1161–1621	2	Not feasible
1162–2082	3	Fairly feasible
2083–2999	4	Feasible
>=3000	5	Highly feasible

(3) Traffic light

Distance to the nearest traffic light (m)	Score	Feasibility
1–100	1	Highly unfeasible
101–200	2	Not feasible
201–300	3	Fairly feasible
301–400	4	Feasible
>=401	5	Highly feasible

(4) Trade center

Number of trade center within 500 meters radius	Score	Feasibility
0–1	1	Highly unfeasible
2–3	2	Not feasible
4–5	3	Fairly feasible
6–7	4	Feasible
>=8	5	Highly feasible

(5) Financial center

Jumlah Financial center dalam radius 500 m	Score	Feasibility
1–2	1	Highly unfeasible
3–5	2	Not feasible
6–8	3	Fairly feasible
9–11	4	Feasible
>=12	5	Highly feasible

(6) Education center

Number of education center within 500 m radius	Score	Feasibility
1–3	1	Highly unfeasible
4–7	2	Not feasible
8–11	3	Fairly feasible
12–15	4	Feasible
>=16	5	Highly feasible

(7) Social center

Number of social center within 500 m radius	Score	Feasibility
1–3	1	Highly unfeasible
4–7	2	Not feasible
8–11	3	Fairly feasible
12–16	4	Feasible
>=17	5	Highly feasible

(8) Houses

Number of houses within 500 meters radius	Score	Feasibility
1–680	1	Highly unfeasible
681–1261	2	Not feasible
1262–1842	3	Fairly feasible
1843–2423	4	Feasible
>= 2424	5	Highly feasible

The final step is data aggregation or by sum up the multiplication result between weighting value and standardization value with formula (1). After all of those three steps is performed, index value will be obtained with minimal value is 1 and maximal is 5. Interpretation from the result of feasibility index is provided in Table 3.

Table 3 Interpretation of Feasibility Index

Feasibility Index	Interpretation
5	Highly feasible
4	Feasible
3	Fairly feasible
2	Not feasible
1	Highly unfeasible

5. Result and Discussion

5.1 Result

Result from this DDS is a software system created by using Arc View, Visual Basic, and Map Object. The display of the software discussed here is as follow:

(1) System display

The main display of the system is the whole based map of assessment are, oil station map, traffic light map, social center, financial center, and trade center as shown in Figure 7.

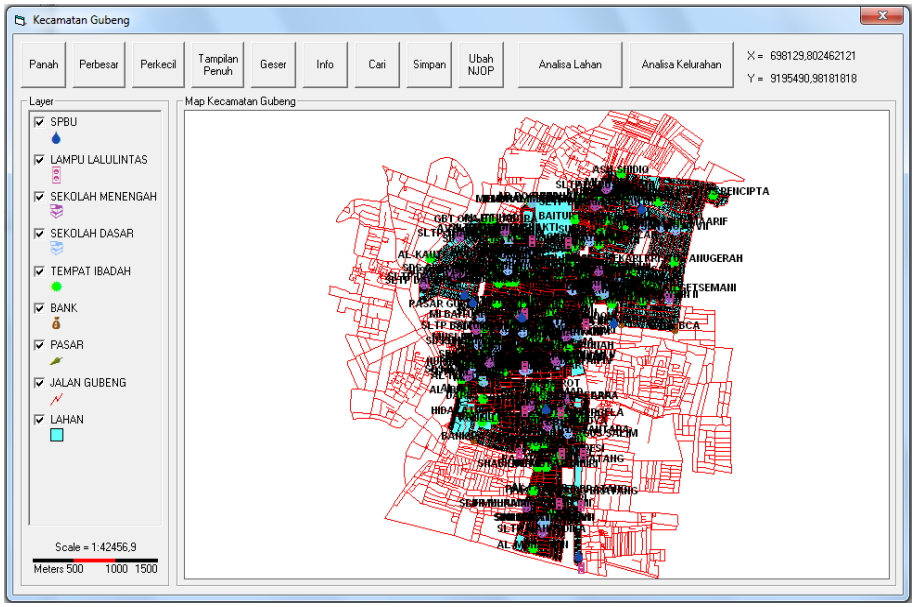

Figure 7 Main System Display

Some tools that exist in the main system display is a map display setting such as Zoom in, Zoom out, Pan, and Info. Moreover, there are several land selection tool, land analyses and region analyses.

(2) System input

There are two kind of system input. First the determination of land location, then the assessment of feasibility will be conducted towards that selected land. Second is the determination of area and then will provided several lands that are feasible for oil station establishment. As for the first one, output display is shown in Figure 8.

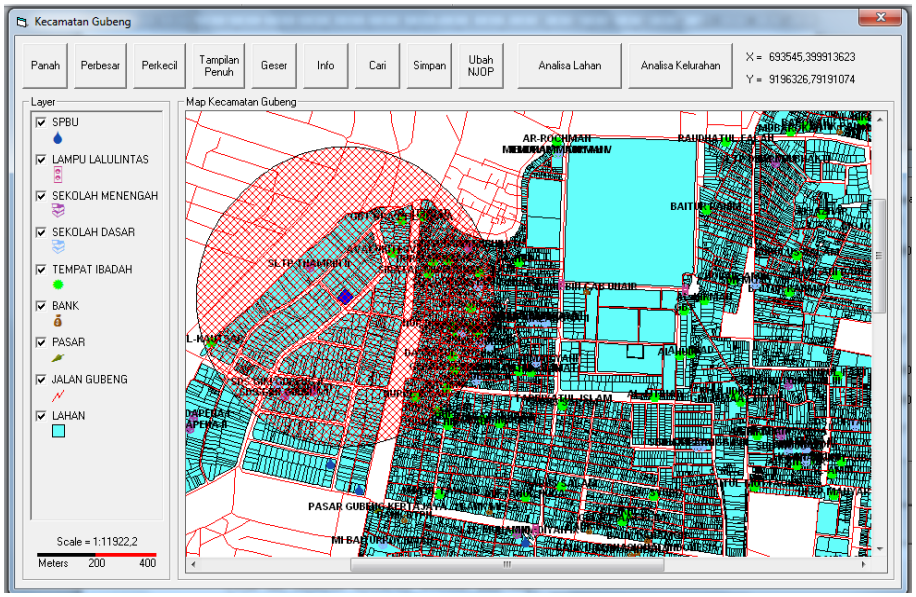

Figure 8 Input of a Land to be Assessed

While the second input is some particular region, which will provide several lands that feasible for new oil station. This input is shown in Figure 9.

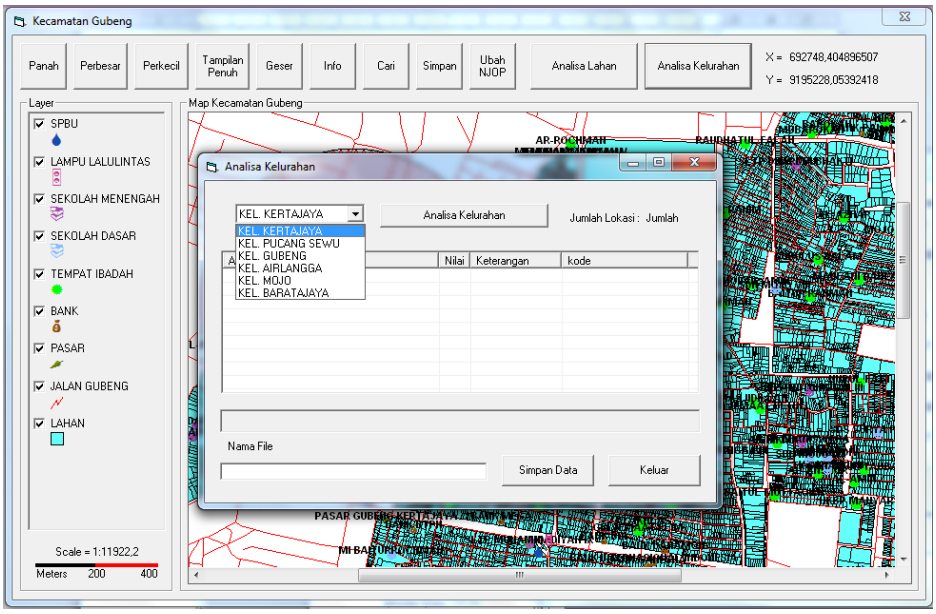

Figure 9 Input of Particular Region to Assess Several Feasible Lands

To perform the second input is by doing pull down menu, with select particular region in the assessment area in Gubeng district.

(3) System output

There are 2 kinds of output, first is feasibility output from a location as shown in Figure 10.

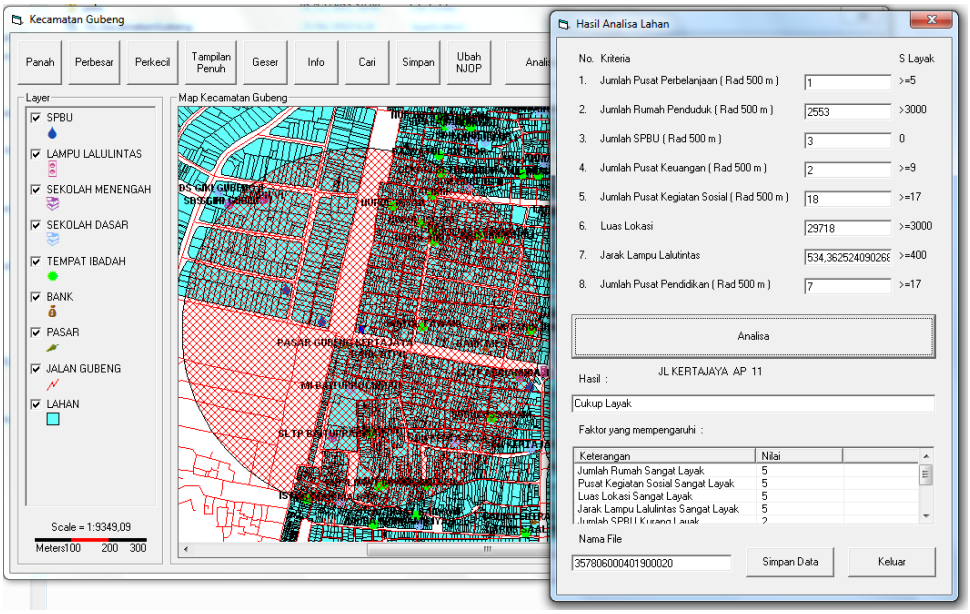

Figure 10 Feasibility Input of One Location

Location feasibility output from a land will provide several feasible lands for new oil station as shown in Figure 11.

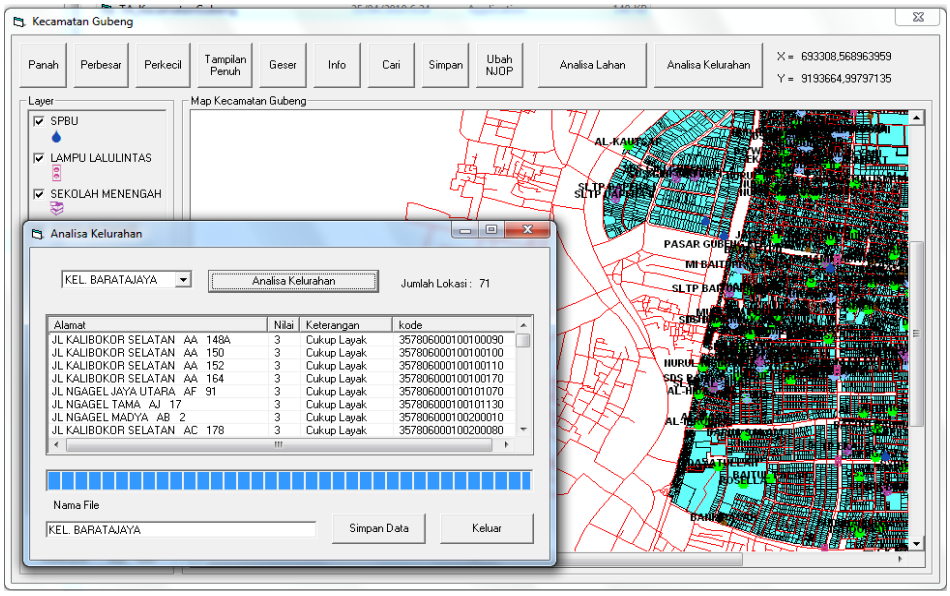

Figure 11 Location Feasibility Output in Baratajaya Sub-district

Baratajaya has 3845 lands lot, and based on the feasibility criteria established of one location for new oil station, there are 71 location that are feasible for oil station, as shown in Figure 11.

5.2 Discussion

The result of this paper will ease PERTAMINA to approve or reject license application foe new location for new oil station in Gubeng District. Compare with similar model design by Nayan (2006), the difference lies on its methodology. The conceptual framework of Decision Support System for Location of New Gas Station in Seberang Perai, Malaysia by Nayan (2006) shown in Figure 12.

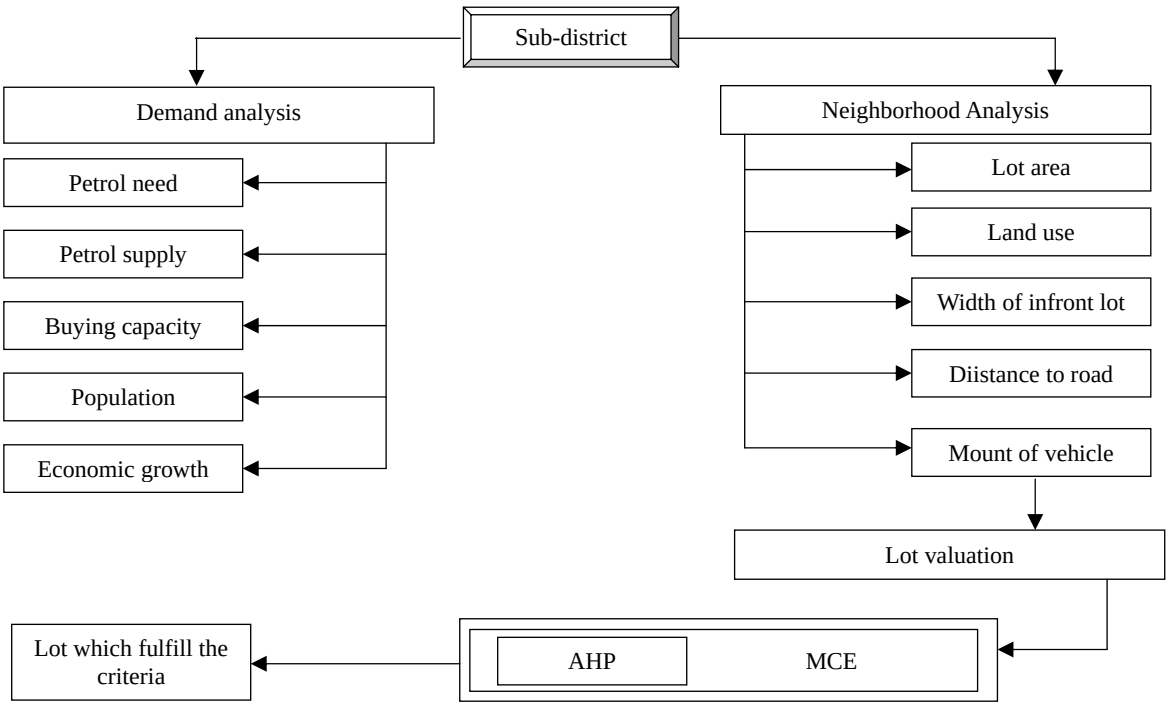

Figure 12 Conceptual Framework of DSS for the New Location of Gas Station in Seberang Perai, Malaysia by Nayan (2006)

This paper is using index model, while Nayan's version was using Multi Criteria Analysis (MCA) combined with Analytical Hierarchical Process (AHP). Another difference is in this paper there are input of particular location. This system used combined tools between programming language Visual Basic and Map Object, while Nayan's version was using Avenue language in Arc View.

6. Conclusion and Future Recommendation

6.1 Conclusion

The main problem in this paper was how to form Decision Support for the new oil station based of Geographical Information System. Therefore the conclusion will be the analysis of new location candidate with the approach of demand and competition which able to create one system for assessment of oil station's new location. Decision Support for the new oil station based of Geographical Information System can visualize earth surface condition in a digital layer. It will ease the users both in deciding the land location that will be analyzed and to interpret the result because there are only 5 index (Highly unfeasible, not feasible, fairly feasible, feasible and highly feasible). Based on the result from Decision Support for the new oil station based of Geographical Information System, PERTAMINA now will able to use the system, to perform a proportional oil distribution based on demand level so that the competition will be fair in Gubeng district. This model also can be use in the other region with some modification, especially within the radius of new oil station. Every region will have a special characteristic, for a region with low people density then radius from oil station location can be enlarged, and vice versa.

6.2 Future Recommendation

There are several factors that had an impact on demand level, while in this paper there are only five factors studied which are the number of trade center, houses, education center, financial center and social center within the 500 meter radius. Another demand factors such as people purchasing level, the products price, the price of product substitution etc was not being studied in this paper yet, hence in future research the factors that affect demand level can be expanded. And so about competition level and the ease of location accessibility, there are more factor that had an impact on those two things while there are only three factors studied here, they are numbers of oil station within 500 meter radius, distance to nearest traffic light and the area of new oil station location. Other factors are ratio between the front yard against location's circumference, another oil station turnover within 500 meter radius, type of oil offered etc has not been used yet in this paper. Therefore for future research those factors can be use for competition level and ease of location accessibility variable to for better research output.

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