Car Park Availability Assessment in Muar Town Using GIS

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Abstract: Parking is an important element in providing a broad range of transportation planning policy in an area. The increasing demand for parking space, particularly in the downtown area requires the provision of adequate parking area, comfortable and safe with regard to the ability of the current land use in urban areas. The development and progress in a certain area will cause problems of the traffic system. The aim of this study was to identify the availability of parking spaces in Muar town, to provide quantitative assessment of parking in Muar town and to analyze the sufficiency of parking spaces in the selected area in Muar town. To achieve the first objective, the analysis was done using ArcMap, afterwards, the questionnaire was distributed to residents in Muar to achieved the second objective, and the third objectives was achieved by using Erlang's Loss Model. From the results of studies using GIS software, areas of parking around the government offices and banks in Muar are digitized. This enables the residents in Muar to park their vehicles close to the destination they want to go. In addition, through the results obtained from questionnaires and Erlang's Loss Model, it is found that Muar has a shortage of parking problem. Therefore, some suggestion is given so that this problem can be solved by the authorities such as build a multi-storey car park and provides a manual of parking location to residents in Muar.

Keywords: Parking, GIS, Erlang's Loss model

1. Introduction

Public and private parking space which is one of the important parts of a modern urban transport system plays an important role in decreasing the load of heavy traffic. Lack of enough accessible parking spaces can hurt local business and decrease the quality of life of residents. Suitable site selection for parking spaces increases parking efficiency and indirectly results in an increase of traffic fluency. Urban areas with a high density and limited land use, require the provision of spaces remaining for vehicle access to the distribution system between the movement and parking of vehicles. Provision of parking spaces along the roadside reduces the capacity of the road and this affects the level and quality service of the road. Thus, studies of parking should be used to determine the level of supply and demand for parking facilities, and the views of the users of the car park to find a solution to resolve the issue.

The geographic information system (GIS) is a computer-based tool for visualizing, mapping and analyzing geographic phenomenon that exists on the earth. GIS is a technological tool designed to evaluate the spatial data [1]. Geographic Information System (GIS), as a science of analysis of spatial and attribute data, is an efficient tool to find optimum place for public parking [2]. As GIS is a very useful tool, many private firms and government agencies in Malaysia have started to use and implement GIS in their daily work. Among government agencies use GIS equipment and facilities are the Department of Survey and Mapping, Department of Forestry, Department of Agriculture, Petaling Jaya Municipal Council and the Ipoh City Council [3].

2. Parking

The parking system is a branch of engineering, and it is one of the tasks of Traffic Engineers. It is important to make a study of parking to find out whether it is adequate for current needs or not. Parking is defined as a placement or storage area for vehicles that does not move and the act of stopping and disengage a vehicle and leaving it unoccupied. It is a convenience for motorists to park or store a vehicle to run their own affairs. The less space in urban areas has increased demand for parking space, especially in the business district. Lack of off-street parking in most of urban centers and inefficient traffic management have been led to parking problems especially in cities.

2.1 Graphical Information System (GIS)

Geographic Information System (GIS) is a computerized information management system for information management, processing, analysis and production of information related to spatial and attribute. GIS requires software, hardware, databases, procedures and skills from person to manage the information. GIS can be used for various applications including geospatial data [4]. The information is controlled using a combination of information systems operation involving planning, observation, collection, management and analysis of data to produce information that can be used in the decision making process. The use of GIS can be proved in various fields such as science, engineering, construction, local authorities, social, national defence and the army. In universities and colleges, students are increasingly interested in GIS courses that are offered either at the undergraduate or graduate program. Rohani (2003) have used GIS to develop a database of traffic by using GIS. Through this study, all data and traffic information can be stored in an orderly manner and allow maintenance and control of traffic road can be done perfectly. Besides that, the traffic situation for the future can be predicted

2.2 Erlang's Loss Model

Theory of queues is a mathematical theory of waiting lines. Queueing theory was born in the early 1900s by A.K Erlang that working in Copenhagen Telephone Company. He has produced some important formula for Teletraffic Engineering. This formula is not only used for communication but also include air traffic control, military logistics, design of theme parks, and many areas involving service systems that are in demand at random. Formula that is used in this study are as follow:

$$P_n = \frac{\rho N / N}{\sum_{i=0}^{N} \rho^{i/i}} \ \text{for } n = 0, 1, 2..., N \tag{1}$$

where P = Probability, and N = Spaces are occupied.

3. Methods

The methodology in this study is divided into 5 levels. It covers the identification of research information from an objective of the study and the problem statement. Then, it will be supported by the information placed in the literature review. After that, all data such as roads, government buildings, banks, parks and housing developments will be sketched based on the information found in Google Earth Pro. Once all the data is imported, the analysis was done using ArcMap. In this stage, the number of parking around Muar categorized into several distances of 50 m, 100 m, 150 m and 200 m away from government buildings and banks. Then, information about the issue involving parking in Muar done through questionnaires and interviews. The results of the information and observations, the probability that customers cannot park because parking is not enough being done using the Erlang's Loss Model.

ArcGIS software is a key element in the GIS to perform each analytic process. Spatial data and attribute data are very important in the development of the complete GIS database. Due to the time constraints, the study area was limited and it is the beginning of the project (pilot project) and will be a reference and guide in the future.

3.1 Digitizing

By using the software Google Earth Pro, every road network, parking locations, the location of government offices, housing, facilities, schools and institutions drawn one by one by using the command line, polygon and place mark (Fig. 1). There are several layers to this study, which is a road layer, a government office layer, the facilities layer, the residence area layer, the bank building layer, the parking location layer and layer of farms and plants. After all the work was completed, a sketch map which contains all the information that has been entered will be produced. Data produced in google earth pro is in KML format. All of this information then is transferred and converted to the layer format in ArcMap 10.
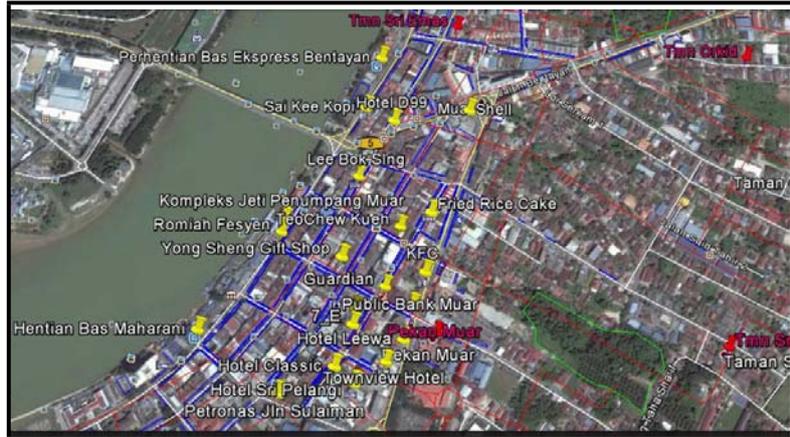
Fig. 1 - Sketch of parking in Muar

3.2 Buffer

Buffer is used for identifying areas surrounding geographic features. For this study, the buffer will be created in each area of government offices and banks so that all the parking around that area can be gathered. Value of the buffer that is designated for each area is 50 m, 100 m, 150 m and 200 m.

3.3 Clip

In GIS, clip is to overlay a polygon on one or more target features which is layers and extract all the information from the target feature data that lies within the area outlined by the clip polygon. In this study, the location of government offices and banks will be clipped together with a nearby parking so that all parking spaces within 50 m, 100 m, 150 m and 200 m from the government offices and banks can be identified.

3.4 Questionnaire and Erlang's Loss Model

A set of questionnaires was provided only as validation for this study. The questionnaire that was conducted is only to prove that the Muar district have a problem of lack of parking. Thus, factor of number of respondents who answered this questionnaire is ignored in this study. Scale was used to measure the position of each question. Scale of 1-5 was used to evaluate the importance of each question where 1 = strongly disagree, 2 = disagree, 3 = moderate, 4 = agree, 5 = strongly agree. A total of 43 respondents were selected to answer a questionnaire, which is made up of local residents.

Erlang's Loss Model was used to determine the probability that a customer is unable to park due to inadequate parking lots and leaves the system or facility. Muar Municipal Council and CIMB Bank was selected to perform this calculation. The time required for the data retrieval process is for an hour. Number of users who entered the building for an hour is taken. The lengths of time a customer at the counter were also taken. Information of total parking has been derived from analysis using GIS is one of the important parameters for this calculation. Once all the data is obtained, the calculation is done using this model.

4. Data Analysis

A total of 9 places around Muar determined in this study, which is the Muar Municipal Council, Jabatan Kerja Raya, Muar Health Office, Registration Department, Department of Evaluation and Property Services, Bank Simpanan Nasional, RHB Bank, CIMB Bank and Bank Islam. Each car parks that are located within 50 m, 100 m, 150 m and 200 m of this place is extracted using GIS software. The analysis results are shown using the attribute queries and multiple ring buffer to identify the parking at a distance of 50 m, 100 m, 150 m and 200 m from each region were selected.

Fig. 2 shows the results obtained using GIS software. Circle of green, blue, yellow and red represents a car park available around government buildings and banks in Muar. Green = 50 m, blue = 100 m, yellow 150 m and red 200 m. After the buffer is created around the selected buildings around Muar, the number of parking spaces are located near the building were obtained using GIS software. Number of parking around MPM and CIMB Bank is shown in Table 1.

Table 2 shows the number of parking spaces for all government buildings and banks around Muar chosen for this study which is within 150 m. This is because, through the results obtained from the questionnaire among the respondents in Muar, a distance of 150 m is the maximum distance and considered appropriate between the parking and the places they want to go.
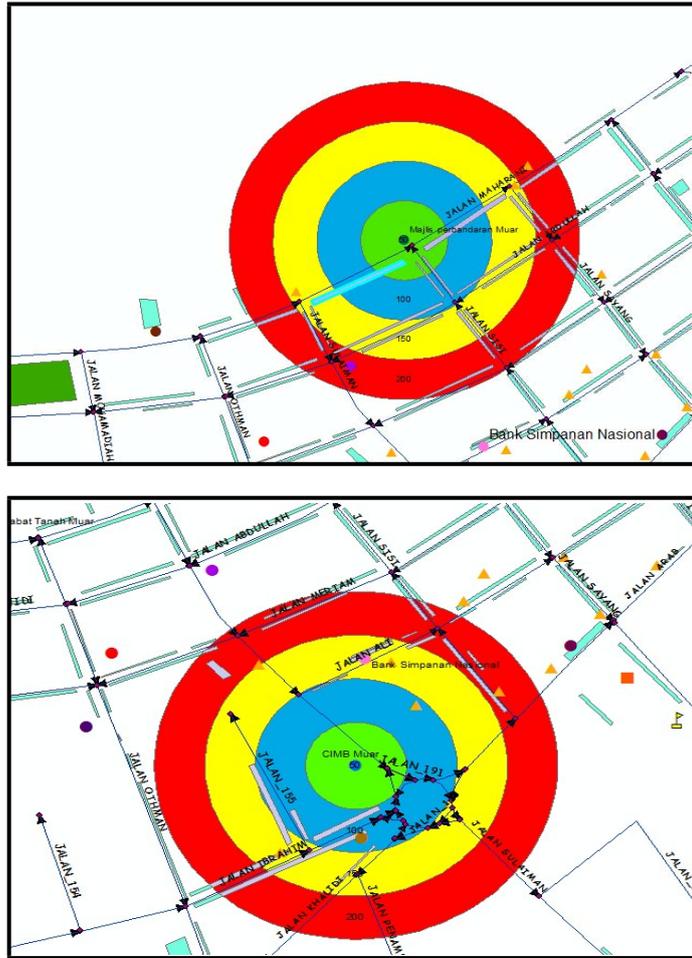
Fig. 2 - Multiple ring buffer at Muar Municipal Council and CIMB Bank

Table 1 - The number of parking lot for each distance at Muar Municipal Council and CIMB Bank

Buildings	Buffer Distance	Parallel	Angled
MPM	50 m	57	22
	100 m	120	32
	150 m	252	66
	200 m	380	93
CIMB Bank	50 m	-	10
	100 m	28	77
	150 m	72	91
	200 m	221	105

Table 2 - The number of parking lot for each distance at government offices and banks in Muar for 150 m

Government Offices and Banks in Muar	Distance	Parallel	Angled
Muar Municipal Council	150 m	252	66
CIMB bank	150 m	72	91
Bank Islam	150 m	209	89
Bank Simpanan Nasional	150 m	166	149
Jabatan Kerja Raya	150 m	149	34
Muar Health Office	150 m	218	52
Department of Evaluation and Property Services	150 m	62	61
RHB Bank	150 m	301	78
Registration Department	150 m	-	36

For CIMB Bank, customers' vehicles arrived at CIMB Bank at random during the morning period (10.20 a.m - 11.20 p.m) at a rate λ of 37 vehicles per hour. With a mean duration of min ($\mu = 4$). Around 50 meter distances from CIMB has 10 spaces (= N), available for vehicles. N= 10 spaces, $\lambda = 37$ arrivals/hr, $\mu = 4$ services, $\rho = \lambda/\mu = 37/4 = 9.25$, and the utilization factor = $\rho/N = 9.25/10 = 0.925$. Using Erlang formula, the probability of car cannot park is $0.0332121 \approx 3.32\%$, (3.32 / 10 spaces) * 37 arrivals = 12 cars.

For Majlis Perbandaran Muar, customers' vehicles arrived random during the morning period (11.45 a.m -12.45 p.m) at a rate λ of 21 vehicles per hour. With a mean duration of 10 min ($\mu = 6$). Around 50 meter distances from MPM has 79 spaces (= N), available for vehicles. $N1$= 28 spaces, $N2 = 29$ spaces, $N3 = 12$ spaces, $N4 = 10$ spaces, $\lambda = 21$ arrivals/hr, $\mu = 6$ services, $\rho = \lambda/\mu = 21/6 = 3.5$, and the utilization factor = $\rho/N = 3.5/113 = 0.031$. Using Erlang Formula, the probability of car cannot park at Muar Municipal Council based on the existing car park is as follows:

Table 3 - Parking lot availability

Car Park	Probability Values	Percent of Values (%)	Number of Cars
P1	0.028434	2.84	2
P2	0.057648	2.76	1
P39	0.052167	5.22	9
P40	0.058244	5.82	12

5. Conclusions

Based on the studies that have been conducted using GIS software, it proves that GIS can be used to determine the number of parking spaces in Muar. In addition, the software also can digitize Muar streets, residential areas, government offices and banks with the help of Google Earth Pro. This shows that, by using this technology, a researcher does not need to go to the research area to investigate and gather information needed for an assessment. This process will save time, energy and money.

After calculation of parking spaces around the Muar Municipal Council and CIMB Bank carried out, it can be concluded that available parking in Muar is less than the demand and cannot accommodate the demand of road users. This will lead to the problem of is inadequate number of parking spaces during peak hours, user who want to park their cars had to wait for an empty space. In this area, the available car park needs to be improved because of rising demand and it involves the interests to the public. The most suitable place for a car park that can meet the demands of the public shall be provided close to a crowded place. However, parking that will be provided usually involve a lot of land and space and this will lead to wastage if the car park was underutilized. So, before a parking place is built, authorities must do some research and a careful planning so that this problem will not happen.

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