A Geospatial Analysis of the Vehicle Parking System in Galle Fort

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Abstract— A proper vehicle parking system is key to the development of transportation systems in growing countries. Studying parking data to exploit flaws and find solutions has also been hindered due to the dynamic nature of traffic and parking data. This research focuses on assessing the efficiency of the existing parking system in the Galle Fort, using parking demand and driver's parking choice behaviour. From the field survey and questionnaires, five locations were identified to cause a lack of parking space during their peak hours and dedicated days. The parking supply information obtained using remote sensing and field surveys was combined with traffic statistics to calculate the parking space demand in the study areas. It was found that the above-mentioned locations caused a lack of parking spaces in the area. By using existing literature, field survey and questionnaires, parking spaces were provided with a user favorability rating based on the orientation of the parking space, condition, safety, ease of searching and shade available to the parking space. Land use and parking demand have a strong visible relationship. Strategic designing of parking spaces is vital as valuable space in a city should be utilized efficiently while incorporating smooth traffic flow. Further information on the attitude of drivers in the region in choosing a parking space can be determined from this research. Taken together, this study provides useful information about the parking system of Galle Fort which can assist in the creation of the future development plan.

Keywords—**Galle Fort, Geographical Information Science (GIS), Parking choice behaviour, Parking demand, Parking supply, Parking system**

I. INTRODUCTION

Galle is one of the famous tourist destinations of Sri Lanka. The Colombo-Galle Road is one of the busiest roads in the country and causes a huge influx of vehicles into the city. With the development of the road network such as the Southern Expressway, vehicle ingress is further increased. This research is focused on the parking system and its efficiency in a study area located in Galle. Vehicles are dynamic and the related systems such as roads and parking are also therefore complex. Vehicles in this research were categorized into two main categories as cars and motorcycles to maintain simplicity in analysis. The category of cars includes personal use Motor Tricycle, compact cars, Sports Utility Vehicle (SUV), Dual Purpose Vehicles, Vans, trucks, and other personal use passenger vehicles excluding buses. As mentioned in Ministry of Transport (2022), motorcycles denote approximately 53% of the total vehicle population of Sri Lanka. The combined categories of Motor Cars, Dual Purpose Vehicles, and Motor Tricycles sum up to about 31% of the total vehicle population. Therefore, it can be safely assumed that the above-mentioned two categories represent most of the total vehicle population of the country and can act as valid subjects to analyze the parking system. The total vehicle population of the country has increased by 1,793,083 from 2015 to 2019. The increase in vehicle population in the country is a major indicator of the importance of parking spaces because every vehicle on its journey should have parking at its destination. Parking spaces can be on road level or multi-level inside buildings. According to Kumara (2015), there exist three main types of parking On-street parking, off-street public parking and off-street private parking. Vertical car parking strategies have also been developed in the world (Simon, 2019). On-street parking takes up a large percentage of parking potential in Sri Lanka. In Gopallawa (2019), Kandy City is considered as the study area to analyze the impact of on-street parking. On-street parking and off-street parking data were collected to analyze the relationship of on and off-street parking with traffic volume. Furthermore, it was identified that increased road width reduces the effect of on-street parking on an increase in traffic congestion. In Amarasingha (2019), research was conducted to provide solutions for parking demand inside the Malabe campus, SLIIT. The research was carried out because insufficient parking spaces promoted illegal parking and occupied the student playground of the campus denying it of its intended purpose. The research also discussed the impacts of illegal parking such as accidents due to tree branches falling and blocking emergency paths.

Lack of parking spaces is a common problem in Galle Fort. During school peak hours, huge traffic congestion arises due to slow-moving traffic searching for parking spaces. This is also caused by the illegally parked cars along the street generating chicanes. The study area included the Galle international cricket stadium. Cricket is very popular in Sri Lanka and therefore a huge influx of vehicles can be observed on match days. Such problems demand effective

analysis of the situation. Prior parking demand calculation of the area can be used to divert traffic flow and create more temporary parking spaces if necessary.

II. METHODOLOGY

A. Study Area

The study area selected included the Galle Fort and Galle International Cricket Stadium. The Galle Fort which is 38ha in extent was considered an archaeological conservation zone in the proposed zoning plan under the "Greater Galle" concept. The area surrounding the stadium is declared a recreational activities zone (Urban Development Authority, 2019). The study area is bounded by the Galle – Colombo Main Road, Kapu Ela and the stadium road. These boundaries are not well defined and sometimes, parking spaces are located just beyond the boundary. Therefore, some exceptions in the study area were allowed.

Figure 1. Study Area
Source: Google Earth Pro

The necessary data to conduct this research was collected using the below-mentioned methods.
- Field Survey Data
- Questionnaire
- Digitizing
- Shapefiles from the Survey Department of Sri Lanka

Parking Spaces shapefiles were not available in the Survey Department of Sri Lanka. Therefore, these were digitized from Google Earth Images and ArcGIS software. The level of accuracy required for parking space shapefiles was easily fulfilled by google earth images as a huge portion of the analysis was concerned with qualitative data. Furthermore (Madarasinghe, et al., 2020), indicates that google earth images are a cost-effective and accurate

method for land use mapping. A questionnaire was conducted through Google Forms. The data obtained from the questionnaire were compared with the data collected in the field.

The efficiency of the parking system in the study area was assessed using two elements found in the literature review, the spatial aspect and the user aspect

B. Spatial Aspect - Parking Deficit/Surplus Calculation

The parking demand was calculated for several location-based scenarios. The scenarios and locations were identified from field data and validated via the questionnaire. The demand was calculated for five selected locations. The peak traffic time and scenario for each location were identified. Data to simulate such demanding scenarios were obtained from field surveys. The traffic statistics were obtained by a limited number of observations for the selected locations. Therefore, it should be noted that the demand is strictly time-dependent. Furthermore, these events are occurring independently from each other.

Table 1. Location-based scenario information

Location	Event	Considered time	Frequency
Samanala Ground	Carnivals & recreational events	Nighttime for approximately a week	Once or twice a month
All Saint's College and Southlands College	School	0630-0800 & 1345-1445 on working days	Every week
Court Square	Food Festival & other recreational events	Total Days for a week	Once every three months
Meeran Jumma Masjid Galle	Religious Activities	Friday 1345-1445	Every week
Galle International Cricket Stadium	Cricket Match	Full day	On days allocated for cricket matches

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The model in the appendix made using ArcGIS gives suitable parking lots for the subject location within walking distance(150m). The statistics function is used in the attribute table to obtain the parking slot supply.
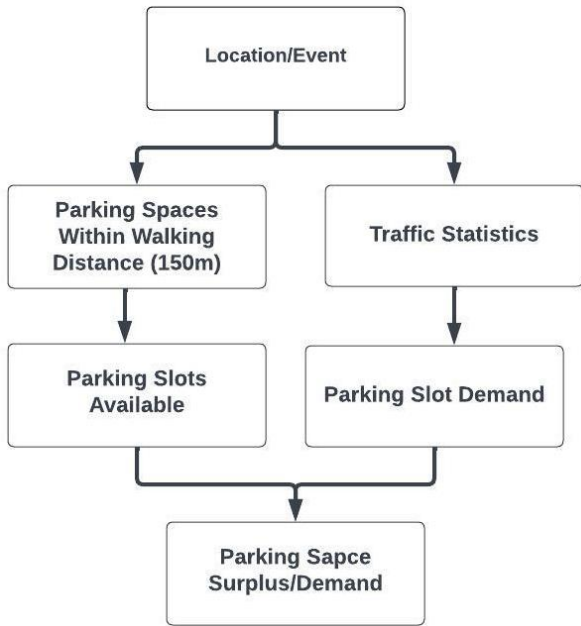

Figure 2. Workflow for Parking Deficit/Surplus Calculation

C. User Aspect – Parking space attractiveness
Several criteria had been established to provide the parking lots with a driver attractiveness factor. A Likert scale from 1-5 was used in the questionnaire to obtain information. Based on other inputs, every factor is scaled from $1 - 5$ where 1 is the least suitable and 5 is the most suitable. Maps were derived using the weighted overlay technique.
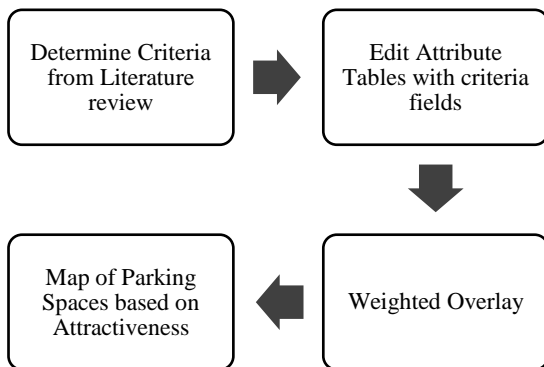

Figure 3. Workflow of determining favorability of Parking space attractiveness

III. ANALYSIS

Table 2. Parking Supply Analysis

Location	Parking Spaces within walking distance	Parking Stalls Available
Samanala Ground	4	136
Schools	10	85
Court Square	5	33
Meeran Jumma Masjid Mosque	3	56
Galle International Cricket Stadium	5	183

Table 3. Parking Surplus Calculation

Location	Peak Hour Traffic Information		Extra Parking Required (Surplus)	
	Cars	*Motorcycles*	*Cars*	*Motorcycles*
Samanala Ground	226	163	124	95
Schools	82	56	18	14
Court Square	128	67	103	51
Meeran Jumma Masjid Galle Mosque	49	72	7	36
Galle International Cricket Stadium	421	395	283	305

A. Criteria for assessing the favourability of a parking space
The following criteria were selected based on the literature review.

1) Parking Space Orientation: The Orientation of the parking space is concerned with the angle between the side of the parking space and the street. As mentioned in Ajeng & Gim (2018) the parking space can be oriented in 5 methods. They are parallel, where the angle is zero and four angled methods with angles of 30 °,45°.60° and 90° respectively. The orientation can alter the parking capacity and affect traffic congestion. Drivers unintentionally prefer to park in parallel or at certain angles, in which they can easily and safely enter and exit.

2) Parking Space Condition: As found (Gopallawa, 2019), drivers are attracted towards on-street car parks rather than off-street car parks to reduce walking distance. The behaviour is almost similar in both peak and off-peak hours. The research concluded that the attraction for on-street parking by drivers is higher than that of off-street parking.

3) Safety Rating: Chen, et al. (2011) studied the behaviour of choosing parking spaces to form a parking choice model. Driver habits and preferences were considered in this research. Safety was given much attention in the considered context of overnight parking in this research. Accordingly, it was considered that drivers are attracted to parking spaces that are video monitored or under good lighting sources. When entering and exiting the parking space, there is a potential for accidents to occur. Of the three methods mentioned, pull-in/back-out was statistically safer (Findley, et al., 2020.)

4) Ease of searching: The parking space should be easily visible to a driver to park his/her car. Parking spots which have all fulfilled all the best conditions may be useless if it is not easily visible to a driver. The logic is that a person wouldn't drive long distances to find a parking spot without being sure it exists. Parking choice modelling, (Chaturvedi, 2012) used the ease of searching car spaces and visibility of car spaces as a criterion for driver attraction.

5) Availability of shade from sun: According to, (Chen, et al., 2011) shade is a factor that most people consider when parking on road level. The drivers do not like a hot interior, that takes a long time to cool down when exiting the parking space. Mostly experienced drivers are concerned about this. They are also concerned about the long-term damage to the paint. Artificial shade is often preferred over natural shade, because natural shade may often increase the probability of being affected by bird droppings.

Table 4. Weights for Parking Space Favorability Criteria

Criteria	Weight (%)
Parking space orientation	13
Parking space condition	23
Safety of parking space	24
Ease of searching	31
Availability of shade from the sun	9

Different Maps on the parking space distribution per each criterion were also created.
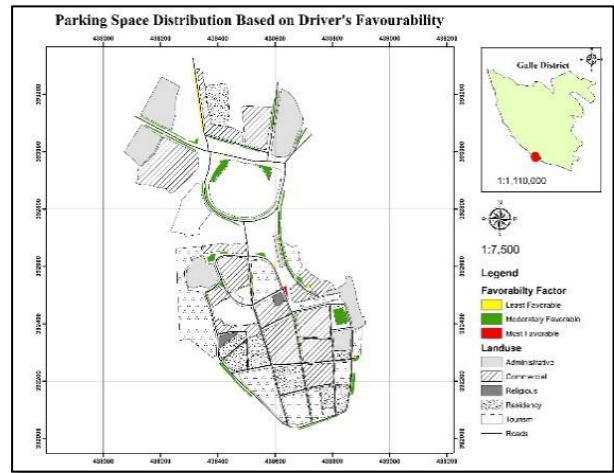

Figure 1: Map depicting the distribution of Parking Space Based on the Driver's predicted favorability

IV. DISCUSSION

The Parking Supply information per each source of parking demand shows different trends in the study area. Many parking slots are available at the Galle International Cricket Stadium. This location attracts a lot of crowds during cricket matches. The initial urban development strategies must have determined this location as such a zone and intentionally added more parking spaces. Though this research does not emphasize the relationship between land use and parking spaces, the parking supply results show certain trends in that relationship.
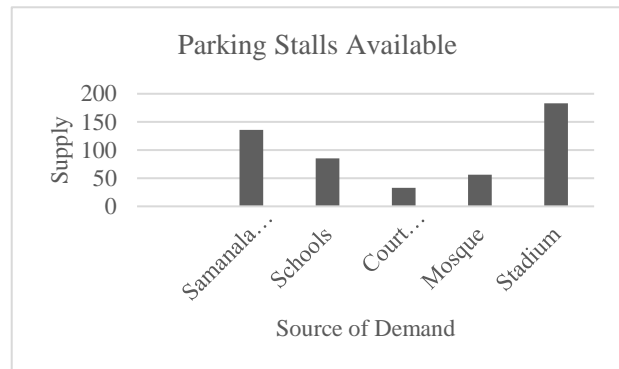

Figure 2: Source of Parking Demand vs Supply

Various works of literature were considered when deciding the criteria for the attractiveness of parking spaces. The factors were provided weights using questionnaire outputs. The provided weights themselves show that ease of searching or visibility of the parking space has scored the highest. As mentioned in (Kumara, 2015) drivers are more concerned about parking the car in a vacated space rather than other factors.

Each criterion in the parking space attractiveness analysis was rated for each parking space using data from a field survey. Maps depicting the distribution of parking spaces

based on each criterion individually were also generated. These maps are attached in the appendix and provided an important analysis of the study area. For example, the distribution of parking spaces based on the safety rating allotted has much practical use. This safety rating was provided using some of the below-mentioned conditions of the subject parking space.

- Presence of Video Monitoring
- Reports on vandalized vehicles
- Reports on thefts of vehicle or vehicle parts

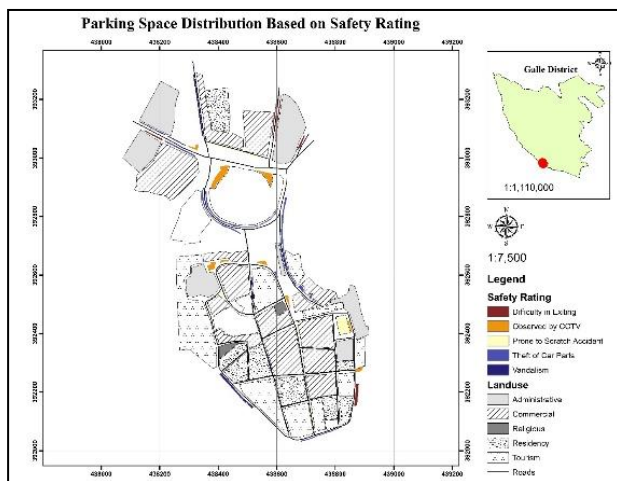The output map can be used by drivers to find the safest parking spaces to park, especially overnight.

Figure 5: Map of Parking Space distribution based on safety rating

The parking space distribution of the study area based on the favorability factor shows some interesting trends. Most of the parking spaces in the study area scored moderately according to the favorability factor it was assessed. This shows that existing parking spaces need small improvements to further attracted drivers.

V. CONCLUSION

Space in the context of urban planning is considered scarce and one of the most valuable elements. Same to the lack of parking, excess parking in a city is inefficient and wastes many valuable spaces that can be used for other necessary elements of a city. Through assessing the parking structure of a city and exploiting its weaknesses, recommendations can be provided to the development plan of the city. An active method of data collection and record keeping of parking capacity could not be observed in the study area. This research provides minimal information on the parking capacity of the area, which can be utilized in pre-planning for holding special events in the study area. The factors affecting the choice of parking lots can also be used effectively in traffic management. If the traffic volume in a certain area is high due to available parking, the traffic can be diverted by demotivating the drivers to park in the subject area. Also, the factors can be used strategically to create parking spaces that attract drivers and creates a good impression of the study area. This can be done to generate income for the administrative sector by strategically placing pay and park systems and parking toll collectors. The Galle Fort, which is an iconic and historical location of Sri Lanka, can utilize the findings of this research to be efficient and create a freely walkable and open space.

REFERENCES

Ajeng, C. & Gim, T.-H. T., 2018. Analyzing on-Street Parking Duration and Demand in a Metropolitan City of a Developing Country: A Case Study of Yogyakarta City, Indonesia. Sustainability .

Bombuwala, B. G. A. & Amarasingha, N., 2019. A Parking Study at Malabe Campus, SLIIT. Journal of the Eastern Asia Society for Transportation Studies, Volume 13.

Chaturvedi, M., 2012. A Geospatial analysis of the efficiency of the parking system, the Netherlands, s.l.: s.n.

Chen, M., Hu, C. & Chang, T., 2011. The Research on Optimal Parking Space Choice Model in Parking Lots. 3rd International Conference on Computer Research and Development.

Findley, D. J. et al., 2020. Safety effects of parking maneuvers. Traffic Psychology and Behavior.

Gopallawa, W., 2019. Study of Behavior and Impacts of On-Street Parking in Kandy Town. Dissertation for the degree Master of Engineering in Highway & Traffic Engineering.

Kumara, B. A., 2015. A study on vehicle user's behaviour leading to parking problems in urban areas, s.l.: s.n.

Madarasinghe, S., Yapa, K. & Jayatissa, L., 2020. Google Earth imagery coupled with on-screen digitization for urban land use mapping: a case study of Hambantota, Sri Lanka. Journal of the National Science Foundation of Sri Lanka, pp. 357-366.

Ministry of Transport , 2022. Vehicle Population. Available at: https://www.transport.gov.lk (Accessed 8 9 2022).

Simon, K., 2019. Vertical Car Parking System, s.l.: s.n.

Urban Development Authority, 2019. Development plan for greater Galle area 2019- 2030, Colombo: Urban Development Authority.

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