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EVALUATE THE ONSITE THREE-WHEELER PARKING REQUIREMENT OF SUPERMARKET DEVELOPMENTS TO MITIGATE THE PARKING-RELATED TRAFFIC IMPACT IN COLOMBO, SRI LANKA

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Abstract: Parking plays a fundamental role in any transportation system, serving as a crucial element in mitigating traffic congestion and enhancing the overall mobility experience. In Sri Lanka, particularly in commercial and shopping areas within the City of Colombo, the issue of roadside parking has emerged as a significant challenge. This predicament has been exacerbated by the spread of private vehicles, especially three-wheelers, which often operate without dedicated parking spaces despite existing regulations in Sri Lanka. This research endeavours to bridge the divide between the legal requirements, as stipulated by regulations, and the actual operational demand for three-wheeler parking in supermarket areas within Colombo, Sri Lanka. By conducting a meticulous comparative analysis and employing statistical tools like SPSS, the study seeks to provide valuable insights into the onsite three-wheeler parking needs of supermarket developments. The ultimate objective of this research is to establish a standardized framework for allocating three-wheeler parking slots within supermarket areas. This framework aims not only to cater to the existing parking demand but also to alleviate the parking-related traffic issues that currently plague Colombo's commercial and shopping areas. In doing so, this research aspires to contribute to the optimization of urban transportation, making it more efficient and accessible for all road users while also fostering sustainable urban development in the vibrant city of Colombo, Sri Lanka.

Keywords: *Parking Requirements, Parking Standards, Supermarket, Three-wheeler, Traffic Impact*

1. Introduction

Two and three-wheeled motor vehicles are significant urban transport modes in many Asian and Pacific regions (Starkey, Batool, & Younis, 2019). More than 70% are in Taipei, China, and also at least half of all motor vehicles are two and three-wheeled motor vehicles in South Asia and Southeast Asia. Thus, two-thirds of all motor vehicles in India, Indonesia, Thailand, and Viet Nam are also the same (Asian Development Bank , 2003). Free availability, less road space occupation, low travel, and maintenance cost (Gopallawa & Weerasekera , 2013), and comparatively low purchase cost (A, Mukherjee, & Mohan , 2001) are characteristics of three-wheelers compared to the other vehicle categories.

Efficient public transportation facilities increase productivity in a city for economic development (Escolano, Dadios E.P. , & Fillone , 2014). Any vehicle that transports people for a fee or reward except a bus, a train, or any other form of public passenger transportation, is considered to be a Para-Transit or Hiring Passenger transport (Ministry of Transport in Sri Lanka, April 2009). So, the three-wheeler can be identified as a Para-Transit mode in Sri Lanka, which provides mainly short-distanced transport services to increase the efficiency of trip distributions (Peiris, Shantha, & Silva, 2016). On the other hand, it is an alternative solution for travelling within congested city areas as a quick and convenient mode (Peiris, Shantha, & Silva, 2016). Moreover, it supports improving the poverty level of the community, especially in developing countries such as Sri Lanka (Amarasingha, April 2015). The three-wheelers are usually known as tuk-tuks, auto-rickshaws, metered taxis, fare taxis, etc.

Parking is a significant and integral part of the transportation system in a city (Toit, Coetzee, Oosthuizen , & Joynt, 2001). Parking demand may prohibit or limit the provision of parking to specific factors (Mackey , Vanzyl , & Vorster) such as size and nature of the development, urban character (Roychowdhury, Nasim , & Dubey , 2018) socioeconomic structure of the population, and residential density, availability of public transport, availability of other on-street or off-street parking in the vicinity, certain combinations of land uses, major pedestrian flows, and scarcity and cost of land (Mackey , Vanzyl , & Vorster). However, parking should be easy to access, find, use, and pay for. Shoup explained in 201 6 that cities should have enough parking spaces by matching the market demand

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(Shoup D. , 2016). However, it could be observed that three-wheeler parks along the road and near intersections have some egative effects on the free flow of the road sections. (Gopallawa & Weerasekera , 2013) explains that these currently adopted practices of three-wheeler parks near improper locations generate harmful effects for vehicle users and also pedestrians. Therefore, (Gopallawa & Weerasekera , 2013) suggests that new rules and regulations should be developed as "a suitable tool" to lessen such adverse influences on road traffic flow.

ESCAP accounted for 2.3% or $ 106 billion of the GDP of the developing and transition economies is the economic cost of road accidents within the ESCAP region (ESCAP, June 2009). These two and three-wheeled motor vehicles are the most vulnerable due to a few causes such as lack of protective covering, younger riding age, minimal training requirements, minimal testing procedures, and relaxed vehicle inspection procedures (Asian Development Bank , 2003).

In the case of Pakistan, rickshaws provide transportation facilities to millions of people across Pakistan. Therefore, rickshaws can be identified as the country's largest informal public transport mode. On the other hand, thousands of people earn their livelihoods from this sector. Most professionals identify that a rickshaw is an unstable and unsafe vehicle type across Pakistan. But, the Pakistan government has not formulated any road safety or transport policy on rickshaws. Hence, experts in the field strongly suggest formulating a "well-defined transport and road safety policy" to mitigate them (Tahir , Haworth , King , Washington , & Akbar , 2018).

Although the provision of parking is expensive for new developments, it has side effects on the current network. Therefore, the parking rates should be sufficient for the developments at the required level and it is care not to provide too much parking (Toit, Coetzee, Oosthuizen , & Joynt, 2001). Insufficient parking can result in overflow or queuing on the road network. And, it may be a reason for illegal parking on the road sidewalks and in the road reserve. Hence, "a parking policy and parking provision requirements are an essential element of any urban transport plan" (Toit, Coetzee, Oosthuizen , & Joynt, 2001).

The minimum parking requirement is a norm for urban and suburban development in the United States Under the reviews (Franco, Cutter , & DeWoody, 2012). Overflow parking will occupy nearby access points, off-street parking may overflow, or else queuing on the road network could be seen as the result of insufficient parking. Moreover, a past study in 2012 has explained that developers practice placing more parking than to provide the absence of parking requirements (Franco, Cutter , & DeWoody, 2012). Moreover, it is no wonder that parking is the primary problem of the urban environment in a large number of cities (especially smaller towns) in current conditions. To solve this parking problem, it is necessary to design parking spaces efficiently and provide the required number of parking lots, especially for commercial developments (Peiris, Shantha, & Silva, 2016). Thus, (Ministry, 2018) noted that by 2050, there will be 1.5 billion motorized two and three-wheelers globally, and they will most certainly continue to play a significant role in urban mobility. Therefore, this research verifies that three-wheeler parking provision is a basic actual requirement in their town planning schemes (Sutandi & Saputro, 2016). Although there is a considerable three-wheeler demand for retail areas at the present social status in Sri Lanka, parking spaces are not provided for supermarket development concerning the regulations in the development zones. Hence, there is a gap in vehicle demand and supply of parking space requirements for three-wheeler vehicle type to supermarket areas in Sri Lanka. Therefore, this research aims to evaluate the demand and supply of parking space requirements for three-wheeler vehicles type with special reference to the shopping areas in Sri Lanka.

2. Literature Review

Supermarkets could be seen as one of the most ubiquitous and homogeneous urban retail spaces in the Sri Lankan context similar to other developing economies. The dominant players in the supermarket sector are Cargills Food City, Keells Super, Laugfs Sunup, Arpico, Softlogic, and Lanka Sathosa, etc. Further, it is having an internationally adaptive retail format to cater to diverse consumer lifestyles (Spotlight: Sri Lankan Modern Grocery Retail, 2 November 2017). Therefore, the number of supermarket developments has rapidly grown in Sri Lanka in recent years (Spotlight: Sri Lankan Modern Grocery Retail, 2 November 2017). Hence, supermarkets are constructed in locations that have high trip attraction rates or easy access points (Amarasingha, April 2015). Therefore, usually, the emergence of stop-and-go waves may be observed at entry and exit points of the supermarkets, due to the vehicle entry and exit of a shopping area (Yamamoto, Hieida, & Tadaki, 2006). Therefore, the transportation facility should be managed at a minimum disturbance to the external transport network. Otherwise, it may highly influence the local economy also. Therefore, this study has touched on retail supermarket developments in Sri Lanka.

Three-wheeler is a popular mode of transport in Sri Lanka for passenger transporting and goods delivery in most urban and rural areas during the last three decades. It has become an essential part of public transportation in the country. On the other hand, it has become self-employment in Sri Lanka (Gopallawa & Weerasekera , 2013). Therefore, people are willing to purchase or hire three-wheelers for their day-to-day travelling. Three-wheelers are mostly used for hiring purposes. However, three-wheeler crashes in Sri Lanka happened to cause respective factors such as the number of three-wheelers, rural/urban nature, the number of vehicles involved in the crashes by day of the week, roadway section, light condition, crashes by road surface condition, age of the vehicle, weather condition, gender and age of the driver, and crash severity (Amarasingha, April 2015). The current statistics show that three-

wheeler accidents are at an alarming level in the transportation sector in Sri Lanka, due to the number of three-wheelers (Amarasingha, April 2015). 46,435 three-wheeler-crashes were recorded on roadways in Sri Lanka during the ten years (Amarasingha, April 2015).

The local authorities assign parking areas to park three-wheelers. However, municipal councils and urban councils have a habit of permitting the three-wheelers to park near congested roads or intersections. A significant increase in accidents caused by three-wheeler parks is proven from the past accident records of Kandy, Mirihana, and Matale police stations (Gopallawa & Weerasekera , 2013). The reduction in exit rate and an increase in average delay were noticeable at the intersections and road sections, corresponding to the increased number of parked three-wheelers. It leads to obstructing visibility, reducing road capacities, blocks the smooth pedestrian and vehicular flow, and generates bottlenecks (Gopallawa & Weerasekera , 2013). Accordingly, if a three-wheeler parks near the supermarket, it may naturally be above issues. To enhance road safety and lessen traffic congestion, it should have stiffer rules and regulations (Dias & Madurapperuma , 2018). Although three-wheeler is having a high vehicle population in Sri Lanka, three-wheeler parking spaces are not allocated for supermarket development concerning the regulations in the development guideline (Urban Development Authority, 2021).

The ever-increasing land cost and development pattern encourage the construction of parking facilities for the development. As a result, there is considerable influence from on-street and off-street parking on traffic flow. Responsible authorities must ensure adequate and effective parking spaces and standards to meet parking demand (Roychowdhury, Nasim , & Dubey , 2018). Although the three-wheeler is not included to determine the parking requirement for supermarket areas in Colombo areas, there is a need to evaluate the topical operational onsite three-wheeler parking requirement concerning the relevant local authority area.

The public transport system encourages buses and auto rickshaws as a traffic management strategy in most cities in India (Aneez, 2010). He illuminates that different standards are provided by some Asian cities for cycle rickshaws. Rickshaw parking facilities are provided at night markets, transport terminals, and schools in the city of Surabaya, Indonesia. Further, three-wheeler parking was constructed at several locations in the Government of George Town, Malaysia. Similarly, Faridabad, India also is planning to develop rickshaw parking slots near major junctions within the city. However, the utilization of rickshaw parking requirements depends on locational factors.

Providing the equivalent car space (ECS) conversion factors is the commonly used method for parking requirement calculation. The requirement for parking has been calculated in terms of ECS, where the amount of parking requirement for vehicles other than cars is transformed into equivalent car spaces based on the proportional area they occupy while parking for a car. The area the vehicle occupies as well as the bare minimum needed to transfer it into and out of the area. ECS, or equivalent car space, refers to this (Roychowdhury, Nasim , & Dubey , 2018). In the case of Delhi, India uses 0.5 ECS for the Three-wheelers parking requirement (Roychowdhury, Nasim , & Dubey , 2018).

3. Method of Study

The shopping area has a high vehicle trip attrition rate in a city (Amarasingha, April 2015). Hence, this research has been used in the Colombo District in Sri Lanka as the study area. The random sampling method is used to select the case locations within the Colombo District. This research conducted a detail analysis of gap between legal (based on regulations) and operational three-wheeler parking requirement for supermarket in Colombo.

Requirement of three-wheeler parking slots for supermarkets was recognised based on the in and out parking survey and field survey results, current parking space standards as per the regulations, analysis of vehicle population data in Sri Lanka, three-wheeler vehicle demand on roads near supermarkets, expertise survey, and in and out & Manual Classified Count (MCC) survey results for parking area of the supermarket. Furthermore, SPSS descriptive statistics analysis was applied.

The Manual Classified Count (MCC) survey conducted in 54 locations near supermarkets, especially near major roads and municipal roads in Colombo District, Sri Lanka to identity the three-wheeler demand for supermarkets in Colombo. Thus, surveys were carried out within 12 hours from 7.00 am to 7.00 pm during weekdays in 2022. The Manual Classified Count (MCC) survey data shows the vehicle accumulation profile (VAP) based on the vehicle classification within the study area. Also, generally, the vehicle accumulation profile (VAP) determines the amount of parking requirement within the study area at different time intervals and vehicle parking types (Diallo, Morency, & Saunier, 2012). Therefore, this survey determines the three-wheeler parking requirement under the theoretical parking capacity.

The in and out parking survey was conducted from 7 to 8 pm (peak hour) at the parking area in 2022 at two locations (Location 01: 6°49'54.5"N 79°52'02.6"E and Location 02: 6°47'51.2"N 79°55'46.5"E) to identify the real parking space requirement for supermarkets in Colombo for three-wheeler vehicle type in Colombo. Parking accumulation, parking index or occupancy, and parking turnover are used to measure the parking requirement of stores. The number of vehicles that are parked at any given time is known as the parking accumulation. The peak

hour of parking and the number of vehicles parked during that time are indicated by the parking accumulation curve (Saptarshi , Ahmed, & Das , 2016). The ratio of the number of bays that are occupied over time to the total amount of space available is known as the parking index, parking occupancy, or efficiency. It provides a general indicator of how efficiently parking space is used (Sutandi & Saputro, 2016).

Parking index or occupancy = (Parking Load/Parking Capacity) ×100
The average number of people who utilize a parking space in a given hour is known as the parking turnover rate (Sutandi & Saputro, 2016).
Parking turn-over = Parking Volume/No. of bays available

The field surveys such as observations and questionnaire surveys (100 customers in each location) at 10 locations and 30 expertise surveys were conducted to measure the parking demand. The secondary data was collected (vehicle population data) from the Ministry of Transport & Civil Aviation, Sri Lanka (2012-2017), Department of Motor Traffic (2016-2019), and (regulations and standards) Urban Development Authority.

Table 1, Conducted Field Survey Locations

Case Location	GPS Location	Case Location	GPS Location
1	6°47'54.5"N 79°54'54.3"E	6	6°47'34.8"N 79°56'49.2"E
2	6°47'58.7"N 79°55'07.6"E	7	6°46'14.8"N 79°53'07.7"E
3	6°47'51.1"N 79°55'46.3"E	8	6°49'54.5"N 79°52'02.6"E
4	6°47'55.2"N 79°55'47.2"E	9	6°53'13.0"N 79°51'51.5"E
5	6°47'45.4"N 79°53'46.5"E	10	6°53'45.3"N 79°56'31.7"E

The vehicle entering and leaving the supermarket at gate location(s) were gathered to confirm the three-wheeler vehicle parking space requirement for a supermarket. All in-out surveys were carried out between 8 a.m. and 10 p.m. (nearly 14 hours) at the parking area under typical traffic flow conditions in 2022. To prevent double counting, traffic data were manually counted based on vehicle classification and simultaneously recorded via a CCTV camera in each store. To streamline the study, only trips made in motor vehicles were examined in 06 locations.

Table 2, Conducted In-Out Survey Locations

Case Location	GPS Location	Case Location	GPS Location
1	6°47'51.1"N 79°55'46.3"E	4	6°49'54.5"N 79°52'02.6"E
2	6°47'34.8"N 79°56'49.2"E	5	6°53'13.0"N 79°51'51.5"E
3	6°46'14.8"N 79°53'07.7"E	6	6°53'45.3"N 79°56'31.7"E

4. Analysis and Results

- CURRENT PARKING SPACE STANDARDS

The majority of local governments impose parking regulations on building owners, as buildings produce demand for parking space (Todd Litman, 2023). Urban Development Authority including the traffic planning committee is the responsible approval authority for providing parking facilities for new development under the Traffic Impact Assessment in Sri Lanka (Urban Development Authority, 2021). The "City of Colombo Development Plan (Amendment)-2008" was the previous legal guide for Colombo Development Area, was declared under Gazette Notification No. 4/1 dated 30th September 1978. It contained provisions in respect of the matters in the Law, and amended and come into operation on 6th February 2008 (UDA, 2008).

Urban Development Authority Planning & Development Regulations 2021, Part I: Sec (I) – Gazette Extraordinary of the Democratic Socialist Republic of Sri Lanka, Gazette No. 2235/54 - 08.07.2021 is the current amended legal document to provide the parking facility for a proposed development in Sri Lanka (Urban Development Authority, 2021). This guide warrants for Colombo City and the outer area which has no special approved development plan. The minimum number of parking space requirements of a new development warrants as per Parking Requirements of Schedule 10, Regulation 73, Urban Development Authority Planning & Development Regulations-2021 based on the vehicle type and other specifications for each development type (Urban Development Authority, 2021).

These regulations frequently tend to be unreasonable, which leaves parking lots underutilized or never utilized entirely, especially in locations with low rates of per capita vehicle ownership and operation (Shoup D. C., 1999). However, in this context, although development plans were amended promptly, there are no legal considerations to having three-wheeler parking spaces for supermarket developments. The parking spaces have been allocated based on the vehicle types such as standard car, two-axle commercial and multi-axle commercial, pedal/motorcycles including disabled parking slots, as per the development type. Consequently, the standard car, two-axle commercial, and pedal/motorcycle parking stalls are only required for supermarkets as per the legal standards.

Table 3, Current three-wheeler parking space standards for supermarket developments

Planning & Development Regulations / Development Plan	Yes	No
Urban Development Authority Planning & Development Regulations - 2021		
City of Colombo Development Plan (Amendment) -2008		
Planning and Building Regulation (Common) -1986		
Planning and Building Regulation (2008-2020) for Sri Jayawardenepura Kotte Municipal Council Area, Dehiwala - Mount Lavinia Municipal Council Area, Maharagama Urban Council Area, Kaduwela Municipal Council Area and Homagama Pradeshiya Sabha Area.		
Development Plan for the Moratuwa Municipal Council Area		

(*Source: Development Plan Division, Urban Development Authority – 2023*)

Parking Requirements
Annexure II (A) of Schedule III

(1) Type of Usage	(2) Type of Vehicles		
	Standard	Two Axle Commercial (Lorry/Bus)	Multi Axle Commercial (Truck Semi)
1. Residential			
i. Flats, dwelling units and terrace houses less than 50 sq.m. in gross floor area	1 for 2 units	-	-
ii. Flats, Dwelling units with Gross Floor Area more than 50sq. m.	1 for 1 unit	-	-
2. Commercial			
i. Retail Shops/Grocery	1 for 50 sq.m.	-	-
ii. Departmental Shops, Shopping Complexes	1 for 50 sq.m.	1 for 500 sq. m.	-
iii. Banks with Customer Services	1 for 50 sq. m	-	-

(iii)
In every development where the total parking requirement exceeds 10 stalls, there shall be 1/3 of such parking requirement of pedal/motorcycles, provided in such development. Such calculation may be considered to the nearest whole number.

Figure1, City of Colombo Development Plan (Amendment-2008) (*Source: Parking Requirements Annexure-II (A) of Schedule III of the City of Colombo Development Plan (Amendment)-2008*)

Seri. No.	Usage	Category	Specifications			Parking Space Requirements			
			Minimum road width (m)	Floor area (m^2)	Minimum land extent (m^2)	Standard Vehicle	Bus	Lorry	Multi Axle
		Retail shops/groceries and similar use	4.5	25	-	One space	-	-	-
			6	50	-	Minimum 2 space	-	-	-
		Retail shops/groceries and similar use	9	-	-	1 space for 50 m^2 (excluding service area)	-	-	-
		Shopping complexes/ Supper markets/ Departmental stores/ Shopping Malls	9	-	-	1 space for 50 m^2 (excluding service area)	-	1 space for 500 m^2 & maximum 2	-
	Commercial	Vehicle Show Rooms/ Tool equipment/ home base	9	-	-	1 space for 200 m^2 and minimum 1 space	-	1 space 200 m^2 & maximum 4	-

Note:

1. In every development where the total parking requirement exceeds 10 stalls, there shall be 30% of such parking requirement of pedal/ motor cycles provided in such development

Figure 2, Planning & Development Regulations-2021 (*Source: Parking Requirements of Schedule 10, Regulation 73, Urban Development Authority Planning & Development Regulations-2021*)

- PARKING ASSESSMENT AND RESULTS OF FIELD SURVEYS

To understand the parking requirements of supermarkets during peak hours, we conducted parking in and out surveys at two different locations. During one of these surveys at location 01, specifically from 7 to 8 pm, a total of 73 vehicles were observed entering and exiting the site.

Table 4, Parking occupancy at location 01

Location 01: 6°49'54.5"N 79°52'02.6"E @ 7pm-8pm					
Time (min.)	IN	OUT	Accumulation	Parking Index or Occupancy	Parking Turnover
5	4	1	7	100.0%	1.00
10	5	3	9	128.6%	1.29
15	3	2	10	142.9%	1.43
20	4	1	13	185.7%	1.86
25	2	4	11	157.1%	1.57
30	3	2	12	171.4%	1.71
35	2	4	10	142.9%	1.43
40	3	3	10	142.9%	1.43
45	5	4	11	157.1%	1.57
50	3	2	12	171.4%	1.71
55	3	3	12	171.4%	1.71
60	2	5	9	128.6%	1.29

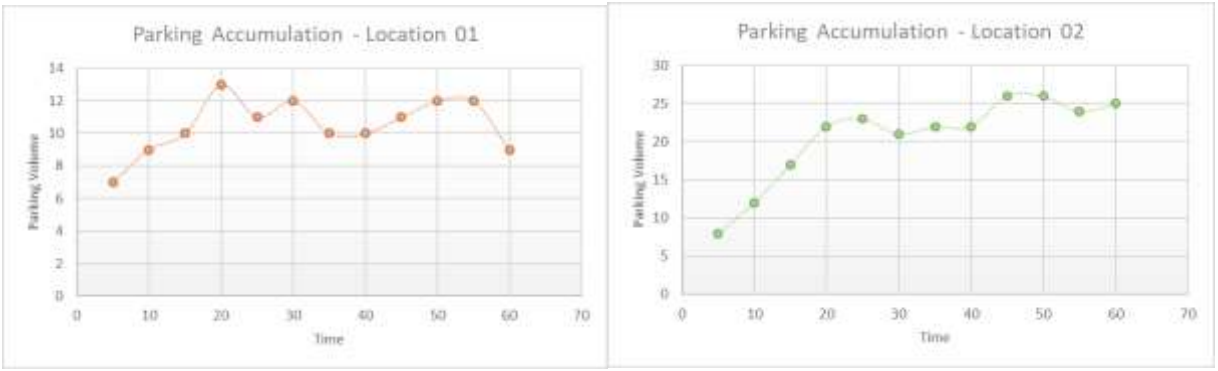

Figure 3, Parking Accumulation

Accumulation curve shows the number of bays occupied with respect to the time. The highest occupied parking amount of the parking space is 13 vehicles at 20 minutes' interval. The parking index or occupancy and parking turnover show how parking space is utilized. Averagely, 150% of parking occupancy level and 1.5 of parking turnover are recorded here. Accordingly, it illustrates the 150% of parking demand for this supermarket, and available parking area is not enough during the peak hour. At this context, vehicle users encourage for road side parking near the shops. Total vehicle in and out is 111 vehicles from 7 to 8 pm at the location 02. As per the accumulation curve, the highest occupied parking amount of the parking space is 26 vehicles at 45 and 50 minutes' intervals.

Table 5, Parking occupancy at location 02

Location 02: 6°47'51.2"N 79°55'46.5"E @ 7pm-8pm					
Time (min.)	IN	OUT	Accumulation	Parking Index or Occupancy	Parking Turnover
5	7	3	8	34.8%	0.35
10	6	2	12	52.2%	0.52
15	8	3	17	73.9%	0.74
20	6	1	22	95.7%	0.96
25	4	3	23	100.0%	1.00
30	3	5	21	91.3%	0.91
35	5	4	22	95.7%	0.96
40	4	4	22	95.7%	0.96
45	7	3	26	113.0%	1.13
50	6	6	26	113.0%	1.13
55	3	5	24	104.3%	1.04
60	7	6	25	108.7%	1.09

According to the above analysis, the parking index or occupancy and parking turnover show how parking space is utilized. Averagely, 89.9% of parking occupancy level and 0.9 of parking turnover are recorded here. Accordingly, it illustrates the nearly 90% of parking land is utilized of this supermarket, and parking area is enough during the peak hour. However, as there is no legal requirement to keep parking spaces for three-wheelers, no specified three-wheeler parking slots are provided by building owners in both supermarket locations. Therefore, three-wheeler drivers practice to park vehicles inside the parking area or near the supermarket premises such as inside the parking area, both sides of the access road, adjust to the gate location/s and nearest junction, etc. It may obstruct the vehicle pattern of the internal and external environment also.

The survey results explain that few supermarket holders and three-wheeler drivers have agreed to have three-wheeler parks inside the supermarket premises by considering the customer requirement without granting legal approval. It strongly justifies the demand of three-wheeler parking for supermarkets. Together, three-wheelers use car parking stalls for their parking. It discourages the parking occupancy at the parking land. Therefore, field surveys identified that wheeler vehicle parking slots are essential parking requirement for supermarkets for their daily business activities. Hence, adopting a regularized (legal) standard for three-wheeler parking is vital to manage and mitigate the travel disturbances at super-markets and the road networks.

Figure 4, Location 01

Figure 5, Location 02

Figure 6, Location 03

Figure 7, Location 04

Figure 8, Location 05

- VEHICLE DEMAND BY HOUSEHOLD IN SRI LANKA

The vehicle ownership percentage varies widely and is influenced by a variety of factors, including management, geography, and demographics (Metro Vancouver, 2012). Therefore, current vehicle population data is very easy to measure the vehicle demand by household in Sri Lanka. Accordingly, the pattern of the vehicle demand by household was identified using the vehicle population data from the Ministry of Transport & Civil Aviation, Sri Lanka (2012-2017) and Department of Motor Traffic (2016-2019). The vehicle population data was analysed until 2019, as vehicle imports were stopped by the Sri Lankan government after 2019 because of the Covid 19 pandemic situation and economic crisis in the country.

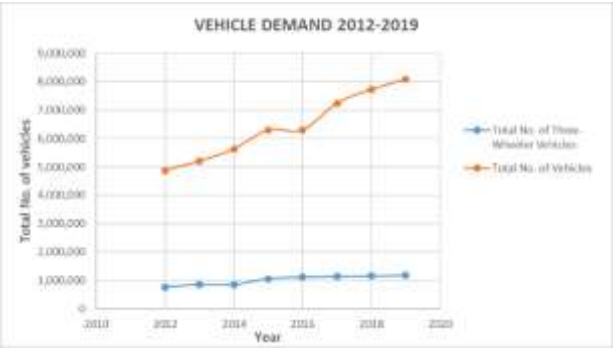

Figure 9, Vehicle Demand 2012-2019

Table 6, Three-wheeler vehicle demand in Sri Lanka

Year	Total No. of Three-Wheeler Vehicles	Total No. of Vehicles	Three-Wheeler Vehicle Composition	Three-Wheeler Vehicle Demand Ratio
2012	766,784	4,877,027	15.7%	0.16
2013	850,457	5,203,678	16.3%	0.16
2014	850,457	5,633,234	15.1%	0.15

2015	1,059,042	6,302,141	16.8%	0.17
2016	1,115,987	6,302,141	17.7%	0.18
2017	1,139,524	7,247,122	15.7%	0.16
2018	1,159,158	7,727,411	15.0%	0.15
2019	1,175,077	8,095,224	14.5%	0.15
2020	1,182,227	8,297,852	15.7%	0.16

Although there is a down in 2016, vehicle demand in Sri Lanka is steadily increased throughout the years. At the same time, three-wheeler demand is slowly increased from 2012. As a results, averagely 15.9% of three-wheeler vehicle composition is recorded from 2012. Therefore, three-wheeler vehicle requirement in Sri Lanka is 1/5 of total vehicle population.

Table 7, SPSS descriptive statistics analysis for three-wheeler vehicle demand in Sri Lanka

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
DemandRatio	8	.15	.18	.1600	.00378	.01069	.000
Valid N (listwise)	8						

As per the SPSS descriptive statistics analysis, 0.15 and 0.18 ratios of total vehicle amount in the country are minimum and maximum three-wheeler vehicle demand in Sri Lanka. Averagely, 0.16 ratio of total vehicle demand is three-wheeler vehicles. Therefore, out of the total required parking for total vehicle, 1/5 number of three-wheeler parking stalls should be provided in every development in Sri Lanka, as per the general vehicle composition and the demand.

- THREE-WHEELER DEMAND OF ACCESS ROADS NEAR SUPERMARKETS IN COLOMBO

Results of MCC Surveys on 54 road points near the supermarkets in Colombo illustrated that averagely 29.88% (30%) vehicles are three-wheelers out of all vehicle types. Thus, 36.89% and 21.19% are the maximum and minimum three-wheeler vehicle compositions in the Colombo area.

Table 8, Three-wheeler Demand of access roads near the supermarkets in Colombo

No.	Road GPS Location	Three-wheeler Composition	Three-Wheeler Demand Ratio	No.	Road GPS Location	Three-wheeler Composition	Three-Wheeler Demand Ratio
1	6°56'31.8"N 79°51'57.1"E	33.18%	0.3	28	6°50'49.9"N 79°55'35.6"E	25.32%	0.3
2	6°56'30.3"N 79°51'53.7"E	30.16%	0.3	29	6°50'34.5"N 79°55'34.5"E	34.20%	0.3
3	6°52'21.3"N 79°51'51.2"E	32.30%	0.3	30	6°54'18.2"N 79°54'49.4"E	26.59%	0.3
4	6°52'19.0"N 79°51'42.6"E	24.10%	0.2	31	6°54'08.3"N 79°54'54.4"E	26.75%	0.3
5	6°52'15.0"N 79°51'35.0"E	26.67%	0.3	32	6°51'02.2"N 79°52'11.7"E	34.11%	0.3
6	6°52'31.5"N 9°51'27.1"E	33.44%	0.3	33	6°51'04.6"N 79°51'59.2"E	35.28%	0.4
7	6°52'13.2"N 79°51'45.9"E	36.37%	0.4	34	6°51'03.6"N 79°51'57.6"E	24.10%	0.2
8	6°52'11.0"N 79°51'46.0"E	34.19%	0.3	35	6°51'01.8"N 79°52'08.5"E	34.37%	0.3
9	6°52'24.7"N 79°51'38.5"E	33.33%	0.3	36	6°53'44.0"N 79°51'25.1"E	31.58%	0.3
10	6°52'27.0"N 79°51'37.5"E	33.45%	0.3	37	6°53'41.1"N 79°51'20.7"E	29.63%	0.3
11	6°52'28.8"N 9°51'36.2"E	34.10%	0.3	38	6°53'42.9"N 79°51'17.7"E	25.92%	0.3
12	6°54'36.0"N 79°50'57.8"E	33.80%	0.3	39	6°52'48.6"N 79°56'49.6"E	27.33%	0.3
13	6°54'36.7"N 79°51'00.1"E	25.90%	0.3	40	6°51'23.1"N 79°53'21.6"E	27.68%	0.3
14	6°54'35.2"N 79°50'55.4"E	22.30%	0.2	41	6°51'21.0"N 79°54'42.8"E	25.32%	0.3
15	6°55'08.0"N 79°51'39.5"E	29.13%	0.3	42	6°52'38.4"N 79°52'50.4"E	33.67%	0.3

16	6°55'06.3"N 79°51'38.5"E	24.60%	0.2	43	6°54'36.6"N 80°05'12.8"E	26.90%	0.3
17	6°50'16.8"N 9°52'02.8"E	24.10%	0.2	44	6°56'20.0"N 79°52'41.8"E	28.34%	0.3
18	6°50'17.3"N 9°51'59.4"E	34.70%	0.3	45	6°56'24.3"N 79°52'38.7"E	33.32%	0.3
19	6°52'18.1"N 9°59'50.2"E	24.28%	0.2	46	6°55'22.0"N 79°52'11.1"E	35.09%	0.4
20	6°48'34.6"N 9°56'21.7"E	26.71%	0.3	47	6°55'21.7"N 79°52'09.2"E	32.53%	0.3
21	6°48'30.8"N 9°56'20.9"E	30.39%	0.3	48	6°48'13.0"N 79°53'05.5"E	35.96%	0.4
22	6°36'31.3"N 9°57'09.0"E	21.19%	0.2	49	6°57'45.8"N 79°52'29.9"E	36.14%	0.4
23	6°52'35.6"N 9°51'36.2"E	36.36%	0.4	50	6°47'17.0"N 79°53'06.2"E	25.92%	0.3
24	6°52'35.8"N 9°51'38.2"E	24.10%	0.2	51	6°48'14.2"N 79°53'08.3"E	36.89%	0.4
25	6°50'19.4"N 79°58'45.9"E	21.66%	0.2	52	6°51'19.8"N 79°53'27.4"E	29.68%	0.3
26	6°50'38.3"N 79°55'33.1"E	32.44%	0.3	53	6°51'19.8"N 79°53'27.4"E	29.97%	0.3
27	6°50'37.5"N 79°55'28.1"E	23.11%	0.2	54	6°55'21.3"N 79°51'56.3"E	35.08%	0.4

Accordingly, as per the three-wheeler demand ratios of access roads near the supermarkets in Colombo, 30% (0.29 ratio) of the total parking requirement, three-wheeler parking stalls shall be provided in every supermarket development in Colombo. Hence, the Equivalent Car Space (ECS) for Three Wheelers is 1/3 in Colombo District.

Table 9, SPSS descriptive statistics analysis for three-wheeler demand

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
RoadThreewheelerDemandRatio	54	.20	.40	.2963	.00791	.05816
Valid N (listwise)	54					

Accordingly, the parking space requirement for three-wheeler vehicle types for a supermarket in Colombo District, Sri Lanka based on the current three-wheeler vehicle demand is an average of 1/3 of total parking slots.

- **THREE-WHEELER vehicle DEMAND for parking in the SUPERMARKETS, COLOMBO**

The vehicle entry and exit analysis for parking shows that an average 30.72% of three-wheelers (0.31 ratio) from total vehicles attracted to parking in the supermarkets. Thus, 33.60% (0.34 ratio) and 25.11% (0.25 ratio) are the maximum and minimum three-wheeler vehicle demand for parking in supermarkets in the Colombo area.

Table 10, Three-wheeler Parking Requirement

Case Location	GPS Location	Three Wheeler Composition	Three-Wheeler Demand Ratio
1	6°47'51.1"N 79°55'46.3"E	33.60%	0.34
2	6°47'34.8"N 79°56'49.2"E	31.90%	0.32
3	6°46'14.8"N 79°53'07.7"E	25.11%	0.25
4	6°49'54.5"N 79°52'02.6"E	33.03%	0.33
5	6°53'13.0"N 79°51'51.5"E	29.97%	0.30
6	6°53'45.3"N 79°56'31.7"E	31.73%	0.32

Table 11, SPSS descriptive statistics analysis for Three-wheeler Parking Requirement

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
InOutThreewheelerDemandRatio	6	.25	.34	.3100	.01317	.03225
Valid N (listwise)	6					

Figure 10, Three-wheeler parking requirement of supermarkets in Colombo

It shows that nearly 1/3 of the three-wheeler vehicle parking requirement is needed for a supermarket development. Therefore, The Equivalent Car Space (ECS) for Three Wheelers is nearly 1/3 of supermarkets in Colombo.

5. Conclusion

The primary aim of this research study is to gain a comprehensive understanding of the demand for three-wheeler parking spaces in the context of supermarket locations. The findings of this study reveal that, among the overall parking requirements, approximately one-third of the parking stalls should be allocated for three-wheelers in every supermarket development within the Colombo District. This underscores the critical importance of establishing and adhering to standardized guidelines for three-wheeler parking to effectively manage and alleviate traffic disruptions both within supermarket premises and on adjacent road networks. Field surveys and expert opinions have highlighted the pivotal role of three-wheelers in facilitating passenger pick-up and drop-off services at supermarkets. Lack of designated areas for these activities can impede the smooth flow of vehicular traffic at entry and exit points of supermarket developments, potentially causing congestion and inconvenience. Consequently, it is strongly recommended that passenger pick-up and drop-off zones be incorporated into supermarket designs, ensuring a seamless and efficient experience for both shoppers and road users.

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