STUDY OF BEHAVIOR AND IMPACTS OF ON-STREET PARKING IN KANDY TOWN

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DECLARATION

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ABSTRACT

Study of Behavior and Impacts of On-Street Parking in Kandy Town

Parking considered as one of the most vital transport facilities in urban Context. The availability of parking relates with the parking location, parking price, parking regulations and parking space available.

In a city, the parking spaces are required by residents, employees, visitors. With the increase in vehicle ownership, parking is becoming a serious problem of cities, especially the historical cities which were not designed for automobiles. This creates a tremendous pressure on parking which results a greater demand on on-street parking in major arterial roads. Despite local government and regulatory bodies have introduced various initiatives with number of policies and solutions for parking in the city, the problems still exist due to inadequate understanding of the root cause of parking problem.

For this study the historical city Kandy is taken as a case study to examine the major problem of on-street parking and find out the root cause through examine the behavior, impact of the parking and the factors that influence drivers on parking.

As part of the methodology, on-street and off-street parking data together with traffic volume data were collected and analyzed to identify the connection between the on and off-street parking with the traffic volume. Further, GIS tools combining with the statistical analysis used to find the demand for two types of parking at the same time, with determine the on-street parking attraction area and average walking distance to the on-street attractive area from the off-street parking area. Results shows that motorists tend to park their vehicles on-street in the morning hours. Also, results represent that users are attractive to park on- street to reduce the walking distance to their destination without parking their vehicles in off- street car park.

Further, impact for the vehicles travel speeds due to the on-street parking were analyzed using a Google map related program which calculates the travel time in pre-assigned road segments developed by the Planning Division, Road Development Authority. The data were analyzed for three parking categories, based on the width of the road segments as narrow, medium and wide. The result shows that rise in the on-street parking cause to reduce the speed of the traffic flow and this is evident in all parking categories. This will assist policy makers to consider on-street parking as a plan of managing the speed.

The study also presents a discussion on policies of parking regulations and possible solutions for parking in the study area. The study envisaged that this would provide a more logical framework to adopt in decision making and making suitable solutions for traffic problem in similar situations.

Keywords: Parking, On-street parking, Off-street parking, Travel speed, Parking management

DEDICATION

To my Parents and Husband

Who always support and encourage me towards the success

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Background

Parking considered as a key transport facility in urban area especially in the central business districts. The availability of parking plays a vital role in Controlling, depriving and encouraging access to the city. With the increase in car ownership, parking is becoming a serious problem of cities, especially in the historical cities which were designed to serve pedestrians and more traditional form of transports. This creates a tremendous pressure on parking which results an increase the demand on on-street parking in major arterial roads. Even though the local government and regulatory bodies has introduced various initiatives with number of policies and solutions for parking in many cities, the problems still exist in many cities due to inadequate understanding of the root cause of parking problem.

1.2 Research problem and the study area

For this study the historical city Kandy is taken as a case study to examine the major problem of on-street parking and find out the root cause through analyze the behavior, impact of the parking and the factors that influence drivers on parking.

Kandy, also known as the hill capital of Sri Lanka, is one of the important historical, cultural, administrative and transport node located 116 km from Colombo, located in a basin on a mountainous terrain at N7 17 37 E80 38 25 at an elevation of 500 m above mean sea level. The city is characterized by the sacred heritage city which represents streets with an orientation towards North-South and East-West, composes of the royal palace, lake, the temple of tooth relic of Buddha, chieftain's houses (Walawwas) and other settlements (Mandawala, 2009). In 1988 the city was declared by the UNESCO as one of the 704 cultural heritage sites in the world.

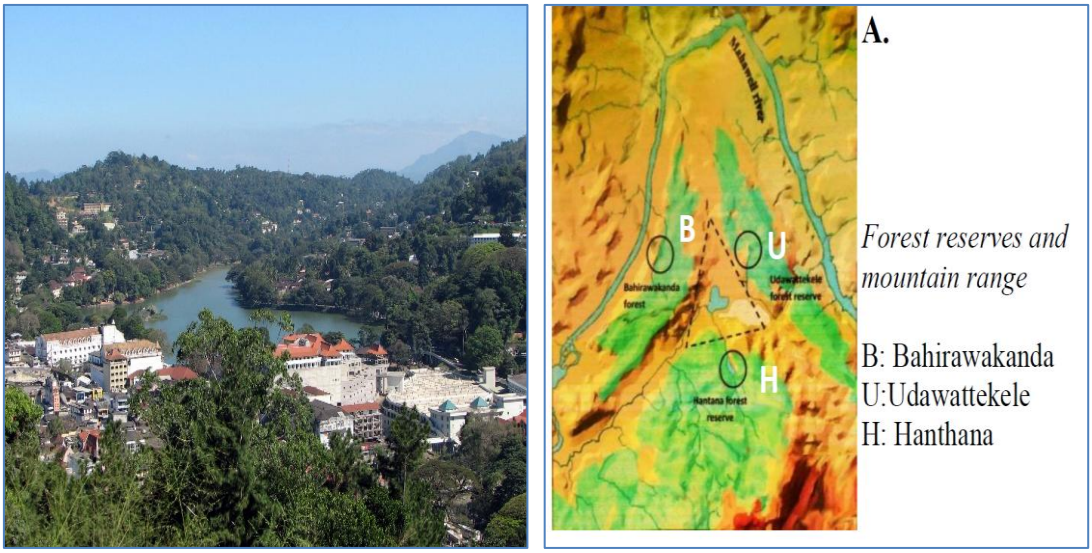

Figure 1.1 : Geographical Features

Source : (FARU,2017)

Today, Kandy is a dense and diversified urban center with a permanent population above 170,000 with estimates 6,000 persons per square kilometer which is highest population density of the central province. The city attracts a daily commuter volume of about 400,000 during the 12-hour daytime for educational, employment, administrative and commercial purposes. In addition, the city receives a large influx local and foreign tourist for religious, cultural and leisure activities.

The city records 40,000 registered vehicles, with a vehicle ownership rate of 255 vehicles per 1000 persons which is twice the national average and with a growth rate of 5% per annum where a doubling of road space required every 14 years (Kumarage, 2014). Jayatilake (2003) in his research measured 33,260 vehicles during the 12-hour daytime entering the Kandy city where around nearly 50% were dominated by private vehicles. Two thirds of this volume was found to enter the city from outskirts. Remarkably, around 15~20% of them were heading beyond the city center to other destinations.

The holistic transport study carried out for Kandy in 2011, Kandy City Transport Study (KCTS), identify the importance of the establishing a proper transportation

system since large disorderly volume of traffic due to increasing traffic demand, insufficient road capacity and local congestion in several areas obstruct the smooth flow of traffic. Parking considered as a key element of the transportation system which plays a vital role in the development of a city. According to Ferguson (2005) parking areas will cover 30% of the built area in residential neighborhoods and 60% in commercial areas.

Many researchers identified parking as a most powerful traffic restraint element which leads to degradation of the urban landscape through increasing land consumption and reducing the open space dedicated to recreational activities and ecosystem services. As Cutter & Franco (2012) illustrates, excessive parking promotes automobile dependency and reduce the efficiency of alternative modes such as public transport, cycling and walking. Further it was identified that the parking could increase the traffic flow together with congestion (Arnott and Inci, 2006), air pollution (van Ommeren et al., 2012), noise (van Ommeren et al., 2012), time delays with the slower vehicle speeds due to parking search (Anderson and de Palma, 2004), and finally safety hazards (Axhausen and Polak, 1989) where , it was identified that almost 15% of all traffic accidents involved on street parking maneuvers , with an average of 40%-60% mid-block accidents.(Weant and Levinson, 1990).

Barth and Boriboonsonsim (2008) identified that the environmental impact of parking primarily associated with increased congestion. Further, driving maneuvers associated with parking, result in greater emissions due to rapid acceleration and deceleration with $_{\text{frequent}}$ stop/start maneuvers. In addition, incidences of idling in search of vacant parking space results more emissions while waiting. (Barth and Boriboonsonsim, 2009).

Figure 1.2 : Present street condition in Kandy city

In recent years, despite many negative impacts to the society, and individual drivers parking is an insufficiently researched area within the city limits of Kandy. The study area defined is illustrates by Figure 1.3 and within the defined area, there are residential buildings, office buildings, commercials, historical sites, schools, government departments, state-owned companies, and museums, etc.

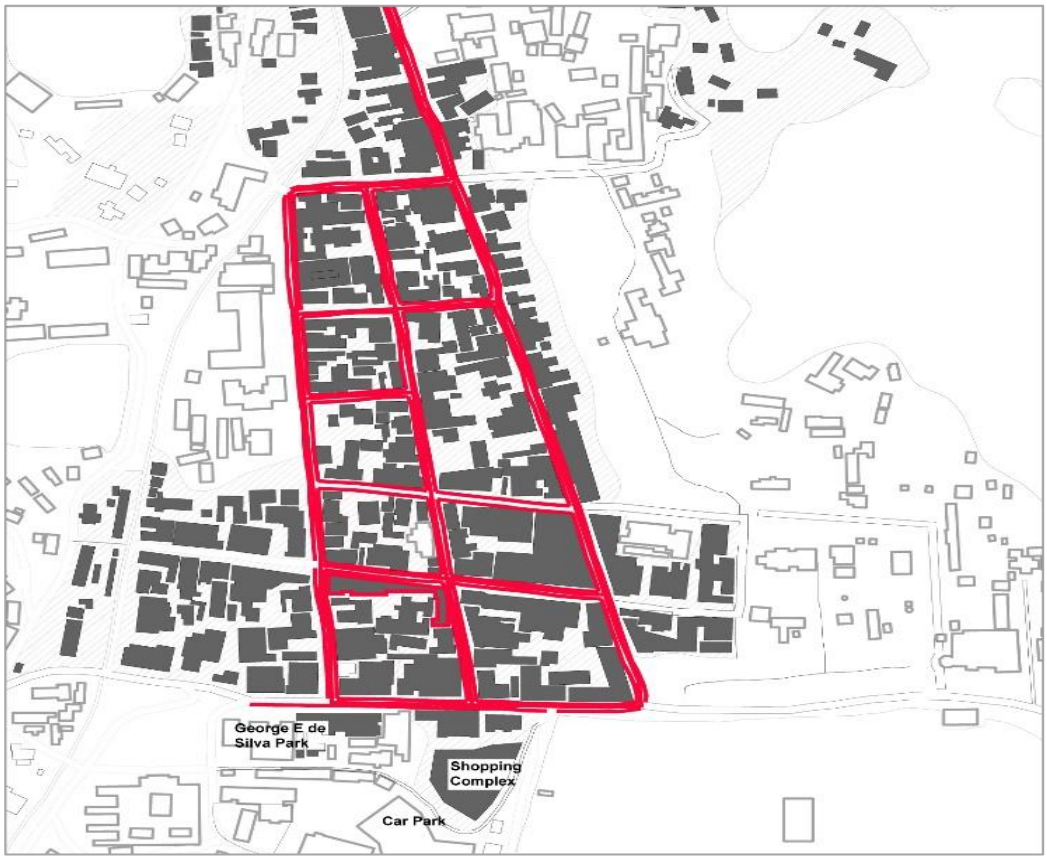

Figure 1.3 : Study area

This area is rich in content with a history of more than 500 years, was designed to serve pedestrians and more traditional form of transports but not for large influx traffic. And even though the area could provide limited parking spaces, with a recent increase parking through a multi storied parking facility, the city could not catch up with the growing parking demand. Further, many researchers found that it will be difficult to implement some advanced parking facilities within the city limits of Kandy since it could result increase land consumption, reduce profits per unit of land and more traffic congestion.

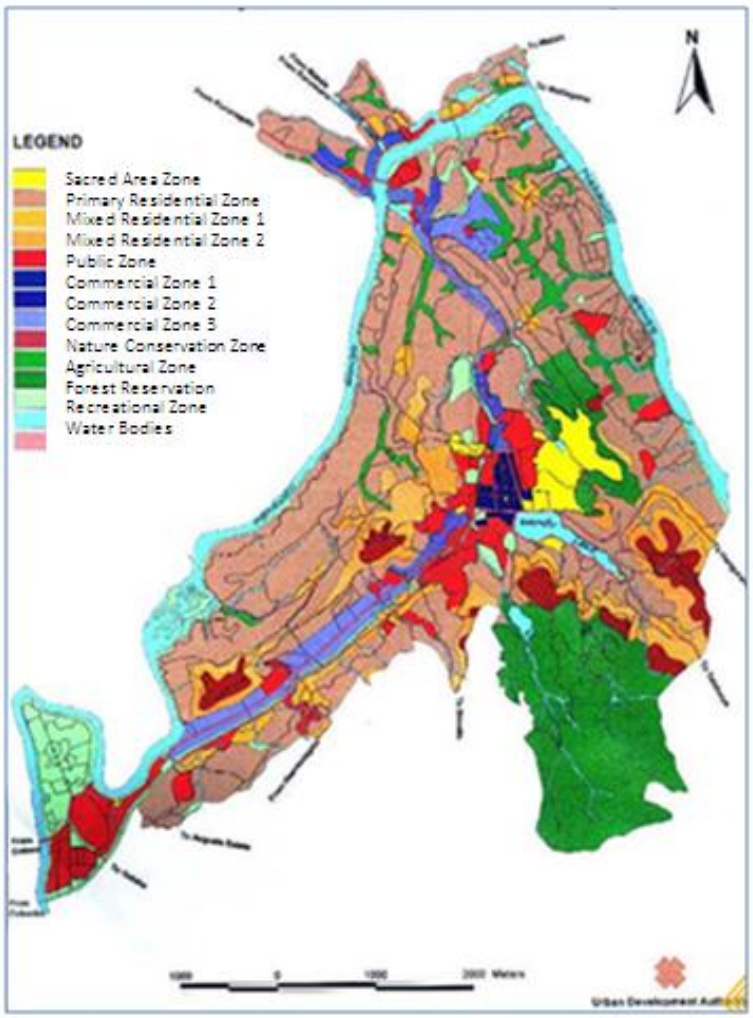

Figure 1.4 : Zoning plan of Kandy city

Source:(http://www.uda.gov.lk/development-plans-reports.html?plan=13)

1.3 Research Objective

The primary objective of this study was to analyze the behavior, impact of the on-street parking and the factors that influence drivers in on-street parking.

1.4 Methodology

On and off-street parking data together with traffic volume data were collected to identify the connection between the on and off-street parking with the traffic volume. GIS tools combining with the statistical analysis used to find the demand for two types of parking at the same time, with determine the on-street parking attraction area and average walking distance to the on-street attractive area from the off-street parking area.

At the final stage of the study presents a discussion on policies of parking regulations and possible solutions for parking in the study area. The study envisaged that this would provide a more logical framework to adopt in decision making and making suitable solutions for traffic problem in similar situations.

2 LITERATURE REVIEW

Parking considered as a key component for transportation and management policy of a city. It can affect land use, traffic congestion, travel speed and behavior, economic development, safety, and air quality of a city. Today Effectively managing parking is considered as key factor for a city due to an ever-increasing demand for space.

2.1 Definition of parking

The term "parking" is defined as an infrastructure forming as a part of the overall process of car travel provided for the storage of vehicles in on or off-street. However, many researches identified a connection between parking and economic development. Today Parking considered as one of the key transport facilities in urban setting and the parking policies & pricing effects the entire land use and transportation. As Donald Shoup (1997) in his article, "The High Cost of Free Parking" Illustrate parking as an unstudied link between transportation and land use".

Many researchers found that parking is becoming increasingly important since every private car typically spend 95% of their lives parked and a every care trip involves two parking maneuvers (RAC Foundation, 2004). Several researchers (Davis et al., 2010a; Feitelson and Rotem, 2004; Arnold and Gibbons, 1996) identified that parking occupies space especially in city centers. The availability of parking has a major influence on the means travel and to determining means of travel and it plays a fundamental role in controlling, depriving and encouraging access to the city. Further, it is identified that the availability of parking has a significant impact to a city even though the location is well served by public transport. However, many researchers identified parking as a most powerful traffic restraint element which leads to degradation of the urban landscape through increasing land consumption and reducing the open space dedicated to recreational activities and ecosystem services. Morency & Trepainer (2008) illustrates that minimizing the of parking in future development is vital to promote sustainable mobility. On the traffic side, on street

parking make significant impact on the traffic flow due to the traffic congestion and delays.

2.2 Classification of parking

Litman (2013) identified two types of parking facilities

1. On-street parking
   a) Parallel parking
   b) Angle parking

2. Off-street parking
   a) Surface car parking
   b) Multistory car parking
   c) Roof parking
   d) Underground car parking

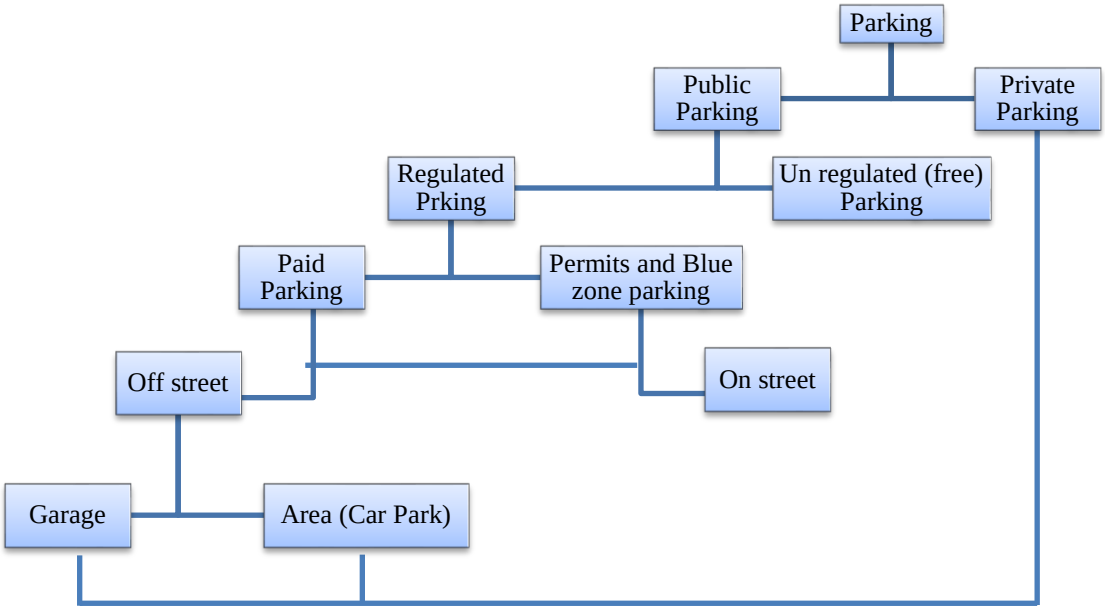

Figure 2.1 : Types of Parking

Bouwfonds (2012) classified the parking with the differentiation of parking activities and types as illustrated in Figure 2.1. Bouwfond (2012) classified parking into 'Public parking' and 'Private parking'. The 'Public parking' is identified as parking facility which is available for the public where as Private parking' aim to support the target groups related to the environment and privately managed.

With the introductory of parking policies and regulations Bouwfonds (2012), further classified the public parking in to two categories namely 'Regulated parking' and 'Unregulated parking'.

Figure 2.2 : On-street parking in Kandy city

In the regulated parking there are two important categories has been identified as paid parking, permit and blue zones. In these categories specific target groups are favored over other drivers by introduction of permits for parking. Blue zone parking' introduces time restrictions and restricts the amount of time available for parking.

In addition, the paid parking regulates the use of available parking through a traffic differentiation. Paid parking activities are located at on and off-street facilities. The on-street parking is placed along the street in the public domain whereas off-street can be considered as public parking on designated areas.

Figure 2.3 : Regulated parking in Kandy city

2.2.1 On-street parking

On-street parking is considered as a key factor in encouraging businesses in a city, especially within central business districts. It can be considered as an effective means of utilizing space allowing multiple users to reach multiple destinations in different times. On-street parking provides efficient access to businesses located on city streets and it accommodate less space than off-street parking. The classification of On-street is given as follows.

1. Parallel parking
2. Angle parking
    a. 30 degree parking
    b. 45 degree parking
    c. 60 degree parking
    d. 90 degree parking

The above classification is based on the parking angle with respect to the road alignment. The Figure 2.4 illustrates the space requirement of parallel and angle parking.

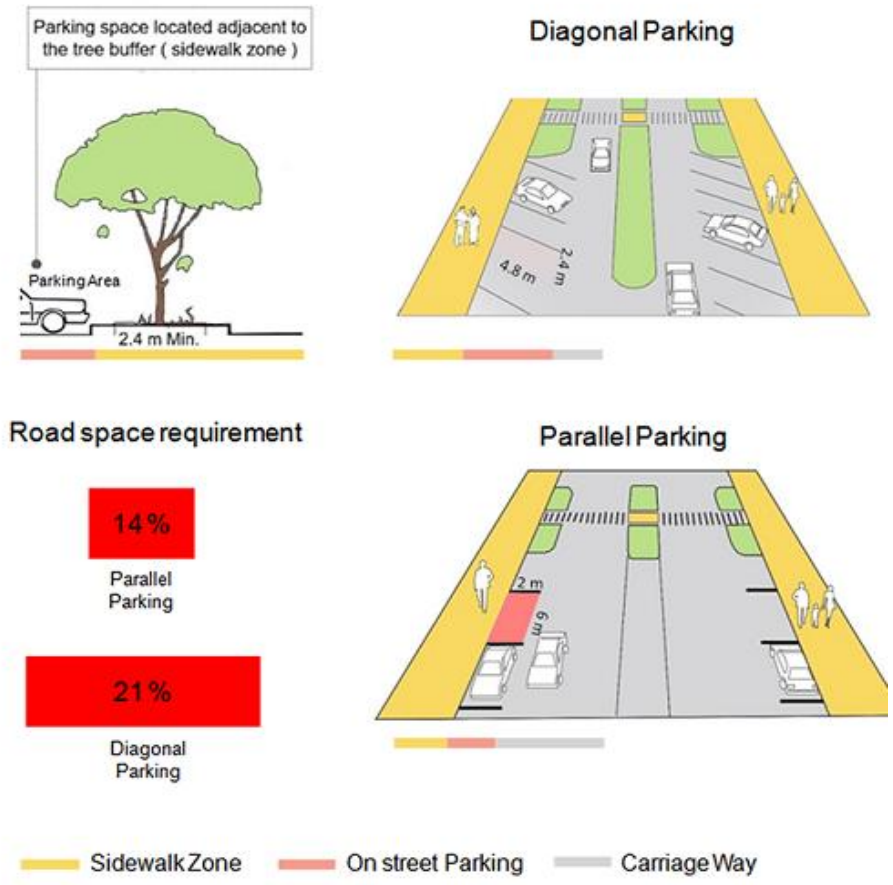

Figure 2.4 : Space requirement of parallel and angle parking

Source: (http://www.theurbanvision.com/blogs/?p=1418)

1) Parallel parking

The vehicles are parked Parallel to the kerb length of the road. It is considered as a safest parking since there is no backward movement involved. As per UDA guideline the standard dimensions of a car parking bay are given as 5.5m x 2.4m. Therefore, number of parking in a given kerb length is reduce. However, this method of parking provided minimum obstruction to the ongoing traffic with the least used road width.

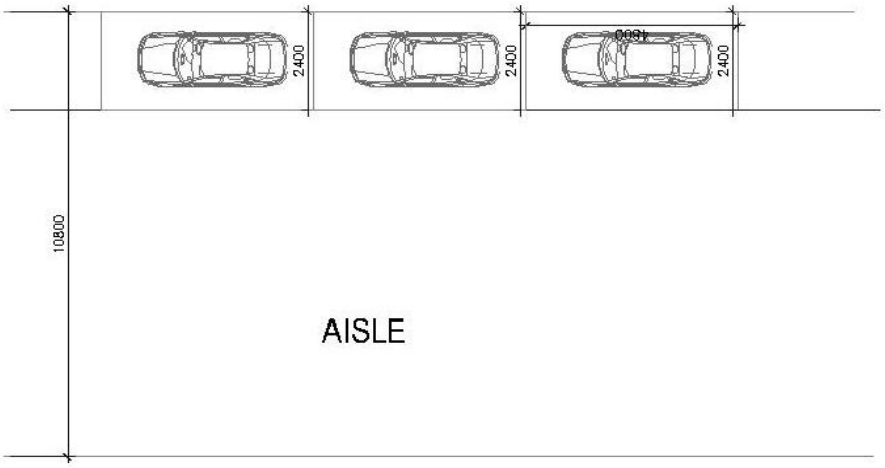

Figure 2.5 : Parallel parking

U.S. Department of Transportation (1982) have analyzed the crash experience between angle and parallel parking and identified that crash rates for parallel parking is 71% lower than those for angle parking. Further, McCoy P.T. et al, (1991) found that transforming parallel to angle resulted in a significant increase in the number of parking-related accidents.

2) Angle parking

i) 30 degree parking

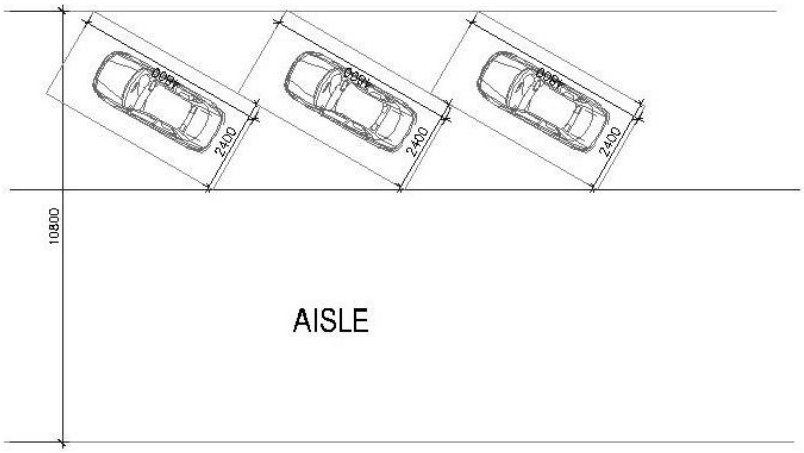

Figure 2.6 : 30degree parking

In 30 degree parking, the vehicles are parked at 30 degrees to the kerb length of the road. It can accommodate more vehicles compared to the parallel parking with better maneuverability. As per UDA guideline the standard dimensions of a car parking bay are given as 4.8 x 2.4m. Further Delay caused to the traffic is minimum compared to 45 degree and 60 degree parking.

ii) 45 degree parking

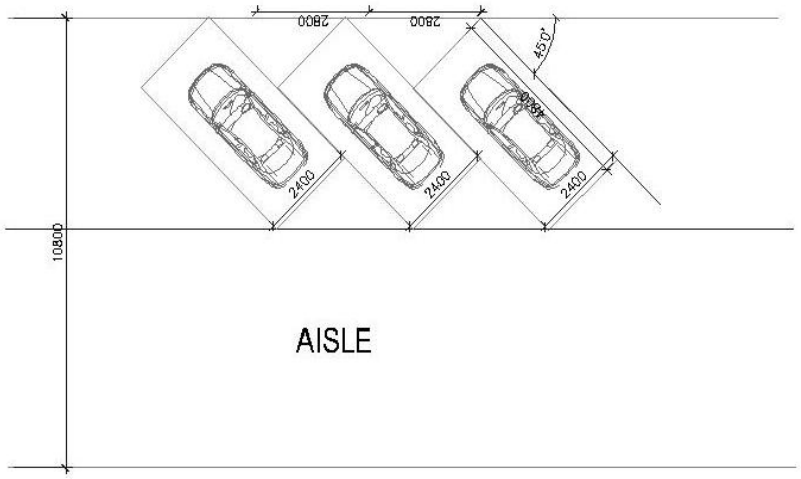

Figure 2.7 : 45degree parking

In 45-degree parking, the vehicles are parked at 45 degrees to the kerb length of the road, where the more vehicles are parked at given kerb length compared to the 30 degrees parallel parking. Further Delay caused to the traffic is higher compared to 30 degree and parallel parking. As per UDA guideline the standard dimensions of a car parking bay are given as 4.8 x 2.4m.

iii) 60 degree parking

In 60 degree parking, the more vehicles are parked at given kerb length compared to the 45 degrees parallel parking. Further Delay caused to the traffic is higher compared to 45 degree parking. As per UDA guideline the standard dimensions of a car parking bay are given as 4.8 x 2.4m.

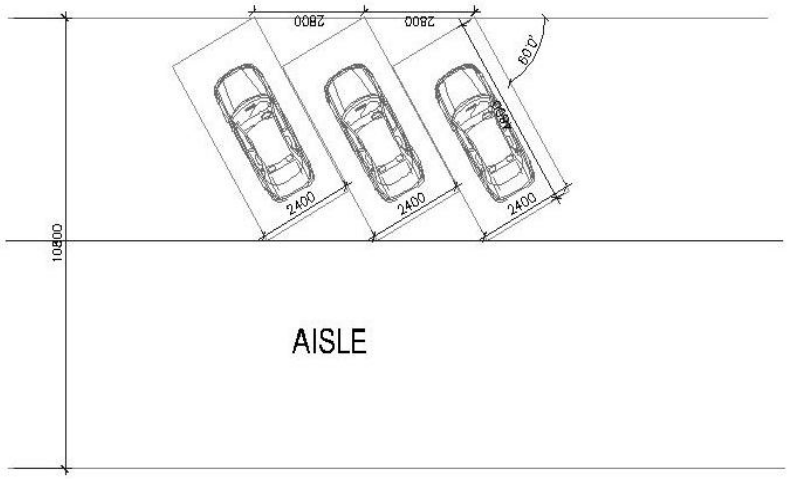

Figure 2.8 : 60degree parking

iv) 90 degree parking

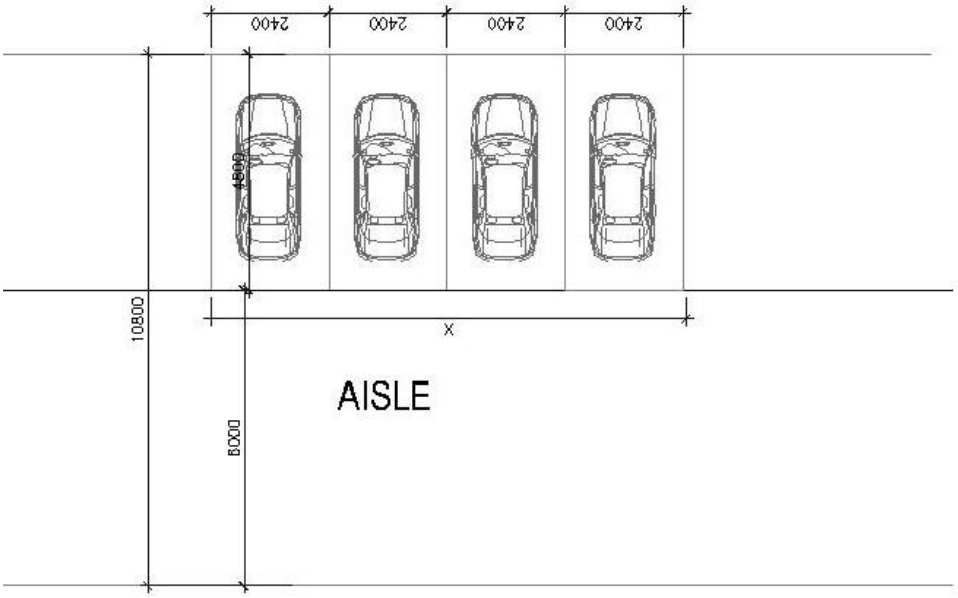

Figure 2.9 : 90degree parking

In 90 degree parking, the more vehicles are parked at given kerb length compared any of the above. However, Delay caused to the traffic is higher. As per UDA guideline the standard dimensions of a car parking bay are given as 4.8 x 2.4m.

However, Zeigler (1971) tested a layout called flat angle, where parking spaces were laid to an angle of 22.5 degree to the curb length. Further Zeigler (1971) observed that Flat-angle parking does favorably affect the capacity of travel lanes and safety compared with angle parking .

2.2.1.1 Effects of Parking

1) Capacity

Many studies show that On-street parking limits street capacity though reducing the effective width of the road and reduce the capacity of the adjacent lanes. Webster and Cobbe on their study on traffic signal design identified that a single parked vehicle caused a loss in the directly equivalent to the width of the vehicle. In addition, parking maneuvers frequently reduce the capacity of the adjacent lanes. The American Association of State Highway and Transportation Officials (1994) illustrates that on-street parking interferes with the free flow of adjacent traffic. Further, Weant R.A. and Levinson H.S. (1990) indicate that the limitation of on-street parking can increase the capacity.

Therefore, The American Association of State Highway and Transportation Officials in their study recommends on-street parking only when traffic demand is well below capacity and travel speed is low. Further, it was noted that the on-street parking is incompatible during periods of heavy traffic movement and higher speeds (AASHTO, 1994).

2) Safety

On-street parking unfavorably influence the safety of the street. A study shows that approximately 20% of all urban crashes are related to on-street parking maneuvers. The literature confirms that angle parking is more hazardous than parallel due to the fact that angle parking has a lack of adequate visibility for the driver during

maneuvering. (Highway Research Board, 1971). Further More recent studies found that approximately 15% of all crashes involved parked vehicles. In addition about 5% of all pedestrian fatalities caused by the people who entered to the road from parked cars (Weant R.A. and Levinson H.S., 1990).) Moreover, Chicago Police Department, (1974) found that vehicles striking parked vehicles accounted for 2% of all fatal crashes, and 6% of all injury crashes.

Further, many sources agree that poorly designed and controlled parking facilities can invite pedestrian accidents due to the fact that parked vehicles can reduce the visibility. However, since the parking lane slows moving traffic it was identified that the crashers are less severe. Many studies recommend encouraging on street parking on low speeds moving traffic. Further, as in figure 2.10, a buffer zone recommends between the parking lane and the walkway to reduce number of accidents.

Figure 2.10 : Parking as a buffer zone

Source: (Los Angeles department of transportation)

In addition, many researchers illustrate that on-street parking may restrict essential emergency vehicle maneuvering as shown in figure 2.11. Chick C (1996) recommends designated on-street parking bays dedicated for the use of emergency

vehicles such as ambulances, Fire engine and police vehicles with proper road markings alongside the parking pay bay to allow the type of vehicle (Chick C., 1996)

Figure 2.11: Restrictions for emergency vehicles

Source: (https://www.itv.com/news/central/2018-02-28)

3) Economic development

M.R. Jr. and Demetsky M.J (1980) identified four types of parking strategies in encouraging economic development. This includes spatial distribution of access to parking, parking control, supply, and price.

The study revealed that the accessibility to the shopping area and the availability of parking were among the key factors in commercial customers decision-making (Innes D., 1990). Further, the placement of on-street parking closer to the commercial areas improves accessibility and convenience to customers plays an important supporting role in revitalization of central business districts.

4) Traffic Calming

On-street parking is viewed as part of the strategy to reduce vehicle speed by increasing side friction. Lerner-Lam 1992 recommends on-street parking for pedestrian oriented neighborhoods as a traffic calming measure, since it act as actual chicanes (Ewing, R., 1999) to reduce travel speed.

Figure 2.12 : Chickane creates by on street parking

Source: (https://web.northeastern.edu/holland2017sustrans/?page_id=527)

5) Environment

In 1976, the Organization for Economic Co-operation and Development claimed that negative impact on humans' health increases with the as the level of traffic increases (OECD, 1976). The interrelation between increase in traffic flows and unfavorable

effects on health due to vehicle emissions has been confirmed by many publications (Whitelegg L. et al, 1993; Royal Commission on Environmental Pollution, 1994). However, it is identified that the properly planned, managed, and enforced parking controls can be used as a restraint measure to reduce traffic volumes and hence reduce the environmental effects (Chick C., 1996).

6) Broad Issues and Concerns

On-street parking have many interconnected issues for the economic development, land use and travel behavior. De Cerreño (2003) has identified the most critical on street parking issues and concerns as follows,

1. Lack of availability with the demand of parking spaces.
2. Travel behavior of residents, visitors, businesses, and other groups.
3. Abuse of disable parking accesses.
4. With the high demand for on-street parking together with insufficient spaces, many drivers wait for availability which results high levels of idling with emissions.
5. Introducing new technologies available for on-street parking.
6. Misuse of parking spaces as most of the commercial vehicles utilizing the spaces inappropriately.

2.2.2 Off-street parking

Off-street can be considered as public parking on designated areas exclusively allocated for parking which is distance away from the main stream of traffic. The arrangement of the off-street parking bay will be parallel, Angle or both from the aisle to maximize available parking.

1) Surface car parking

Surface parking refers to large open areas used for extensive vehicle parking dedicated for parking provided for individuals, official government parking and

short-term drop off. It is commonly located outside the building or a facility shopping malls, sports stadiums, banks offices and etc.

Figure 2.13: Surface parking

Source: (https://www.directasia.com/blog/5-things-singaporeans-should-know-about-increase-in-car-park-rates)

2) Multistory car parking

Figure 2.14: Surface parking

Figure 2.15 : Multistory car parking

Source: (https://www.fraserhallphoto.com/-/galleries/chicago)

Multistory car parking is a building designed for car parking and where there are a number of floors or levels dedicated for the parking.

3) Roof parking

With the increasing demand of the land space, in some cities cars are parked on roof tops of buildings and complexes where the accessibility is provided by a ramp or mechanical lifts.

Figure 2.16 : Roof car parking

Source (https://sf.curbed.com/2018/12/3/18123435/minimum-parking- requirement-development-ban-sf-jane-kim-vote)

4) Underground car parking

The underground parking is a building designed for dedicated car parking in below ground level. The circulation is provided by ramps or mechanical lifts.

3 METHODOLOGY

3.1 Overview of Methodology

In the study area, parking facilities are divided into the following categories.

1. On-street parking.
2. Off-street parking

Location of off-street parking with 850 parking facilities reference to the study area is shown in Figure 3.1.

Figure 3.1: Off-street car park in Kandy city

Parking rates are different among different parking facilities and operated under different authorities. The off-street parking is directly operating under Kandy

municipal council and the on-street parking is leased out by municipality to private agency named EXLANKA Holdings (Pvt.) Ltd.

In order to identify the impact of the on-street parking and the factors that may influence on-street parking, a quantitative method was used in the study area. As part of the methodology, on-street and off-street parking data together with traffic volume data were collected and analyzed to identify the relationship between the on-street and off-street parking with the traffic flow rate. Further, GIS tools combining with the statistical analysis used to find the demand for two types of parking at the same time, with determine identification of the on-street parking attraction area and average walking distance to the on-street attractive area from the off-street parking.

However, dedicated parking spaces such as private and government own parking spaces which are not under municipal operation is not considered in this study even though there is an impact on the overall parking situation and the traffic congestion in the area.

3.2 Data Collection

In the research area 825 parking spaces are available as on-street parking. On-street parking data were collected from EXLANKA Holdings (Pvt.) Ltd from 7:00 am – 19:00 pm for 07th of January 2018. Further, on-street parking count carried out during the previous studies from Planning Division, Road Development Authority and University of Peradeniya was analyzed as a secondary data to consolidated and assess the data gaps.

The streets in the research area were named with node numbering as in Figure 3.2.

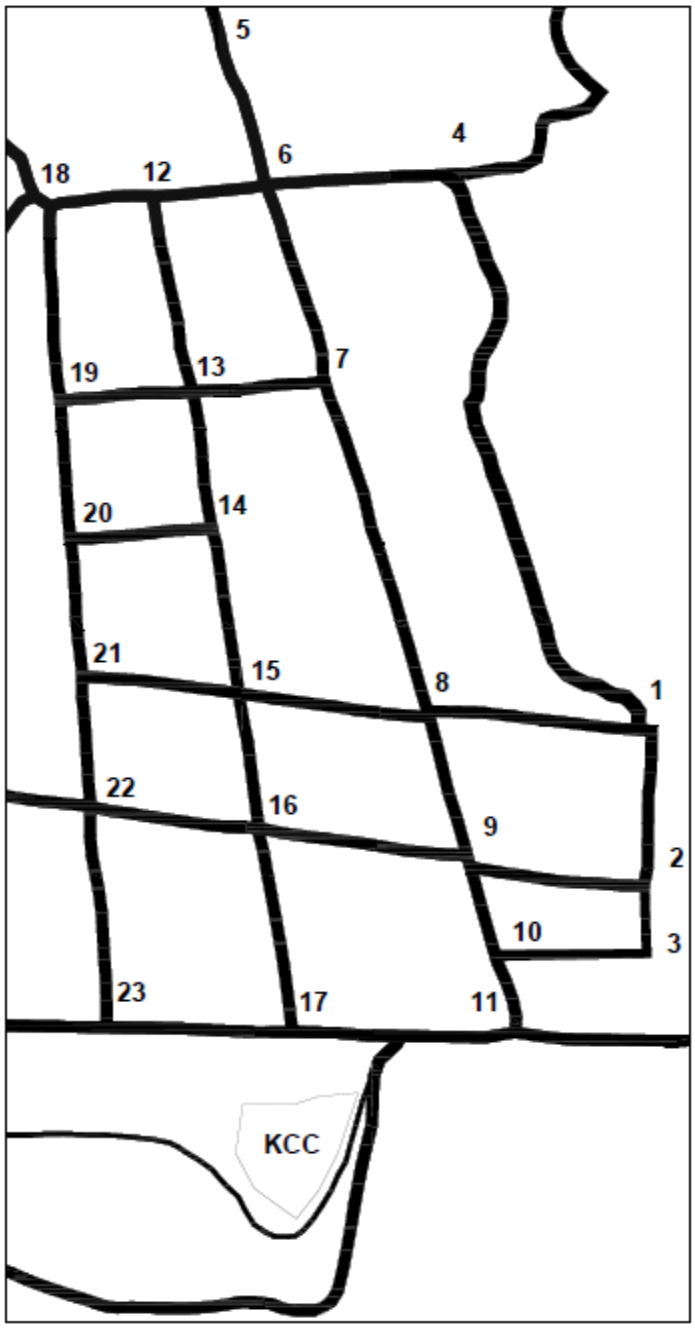

Figure 3.2: Node numbering of street segments

The study region was divided into various segments and on-street parking survey was carried out at all selected road sections. Both parallel parking and angle parking types are using on-streets of the Kandy town and segment details are shown from table 3.1.

Table 3.1 – Street segment details

Street Segment	Length (m)	Width (m)	Type of parking
1-2	100	9.7	Angle/Parallel
2-3	49	9.7	Angle/Parallel
1-8	140	9.5	No Parking
2-9	120	9.9	Angle
3-10	90	9.2	Angle
4-6	150	9.5	Angle
5-6	250	9	Parallel
6-7	150	9	Parallel
7-8	250	9	Parallel
8-9	98	9	Parallel
9-10	65	9	Parallel
10-11	60	9	No Parking
6-12	95	9.5	No Parking
7-13	92	9	Angle
8-15	130	9.5	Angle
9-16	140	9.9	Angle
11-17	145	13.5	No Parking
12-13	150	9	Angle
13-14	94	9	Angle
14-15	110	9	Angle
15-16	99	9	Angle

16-17	140	9	Angle
12-18	50	9.5	No Parking
13-19	82	9	Angle
14-20	93	9.5	Angle
15-21	110	9.5	Angle
16-22	120	9.9	Angle
17-23	148	13.5	No Parking
18-20	220	9.7	Angle
20-23	223	9.7	No Parking

Node 6, 22 and 23 operate as signalized intersections and other junctions operate as unsignalized intersections.

3.2.1 Parking survey

A field survey was carried out on each identified street segment in the research area on length of available parking space, street width, traffic management measures in force, such as prohibited turns, one way streets, etc, and the restrictions that operate along each length of each street segment. Since individual parking space is not clearly defined with road markings. On-street parking data for each road segment from 7:00 am – 19:00 pm for 07th of January 2018 is given in Appendix 1.

3.2.2 Speed data

Real time speed data for the traffic flow were generated through computer simulation from 7:00 am to 19:00 pm (Appendix 2) for selected segments at 30 minutes intervals. Vehicles travel speeds were analyzed using a Google map related program which calculates the travel time in pre-assigned road segments. The program was

developed by the Planning Division, Road development authority and the data input for the program is shown in Table 3.2 below.

Table 3.2 – Street segment input data

Street segment	From	To	Length
8_9	7.295018,80.638023	7.294162,80.638243	98
7_8	7.297147,80.637383	7.295052,80.638011	250
14_15	7.295234,80.636815	7.296239,80.636674	110
13_14	7.296273,80.636666	7.297108,80.636536	94
8_15	7.295045,80.637994	7.295203,80.636850	130
13_19	7.297141,80.636498	7.297089,80.635762	82
14_20	7.296199,80.635823	7.296258,80.636661	93
15_21	7.295230,80.636802	7.295341,80635862	110
7_13	7.297164,80.637358	7.297135,80.636542	92
8_15	7.298341,80,636287	7.297156,80.636506	130
18_20	7,296211,80.635816	7.298211,80.635689	220
12_13	7.298439,80.636994	7.297178,80.637359	150
2_9	7.294144,80.638272	7,294006,80.639305	120

The locations were selected based on the road widths. Roads of different widths, ranging from around 9m to 9.9m, were selected for study. Most of the roads were found to be 9.0 m wide.

The priority was given for the sites where the on-street parking has a considerable effect for hindering the speed of vehicles. There were many streets where there were a few other factors that may hinder the vehicle operations. Street segments 1-2, 2-3, 3-10 which widely used by pilgrims and travelers visiting Temple of Tooth Relic and therefore, these segments were not selected for parking analysis. Also in these segments there is no considerable amount of traffic is moving. Roads that ended at traffic signals or other intersections, sufficient care was taken such that the speeds

were measured at a suitable distance away to minimize their effects, typically there was at least 100m to the nearest intersection. The factors influenced on selecting segments are given in Table 3.3.

Table 3.3 - Factors influenced of selecting street segments for speed analysis

Street segment	**Length (m)**	**Width (m)**	**Type of parking**	**Selected/Not Selected**	**Remarks**
1-2	100	9.7	Angle/Parallel	Not selected	No effective traffic flow occur, People coming for the Temple of tooth relic use these area
2-3	49	9.7	Angle/Parallel		
1-8	140	9.5	No Parking	Not selected	No parking
2-9	120	9.9	Angle	Selected	
3-10	90	9.2	Angle	Not selected	No effective traffic flow occur, People coming for the Temple of tooth relic use these area
4-6	150	9.5	Angle	Not selected	Closed to signalized intersection
5-6	250	9	Parallel		
6-7	150	9	Parallel		
7-8	250	9	Parallel	Selected	
8-9	98	9	Parallel		
9-10	65	9	Parallel	Not selected	Intersection control by police
10-11	60	9	No Parking	Not selected	
6-12	95	9.5	No Parking		
7-13	92	9	Angle	Selected	

8-15	130	9.5	Angle	Selected	
9-16	140	9.9	Angle	Not selected	Closed to signalized intersection
11-17	145	13.5	No Parking	Not selected	
12-13	150	9	Angle	Selected	
13-14	94	9	Angle	Selected	
14-15	110	9	Angle	Selected	
15-16	99	9	Angle	Not selected	Closed to signalized intersection
16-17	140	9	Angle	Not selected	
12-18	50	9.5	No Parking	Not selected	
13-19	82	9	Angle	Selected	
14-20	93	9.5	Angle	Selected	
15-21	110	9.5	Angle	Selected	
16-22	120	9.9	Angle	Not selected	Closed to signalized intersection
17-23	148	13.5	No Parking	Not selected	
18-20	220	9.7	Angle	Selected	
20-23	223	9.7	No Parking	Not selected	

After various site visits and through analysis of the road environments, street segments given in Table 3.4 were chosen for observations.

Table 3.4 – Street segments for the speed data

Street segment	**Length (m)**	**Width (m)**	**Type of parking**
2-9	120	9.9	Angle
7-8	250	9	Parallel
8-9	98	9	Parallel

7-13	92	9	Angle
8-15	130	9.5	Angle
12-13	150	9	Angle
13-14	94	9	Angle
14-15	110	9	Angle
13-19	82	9	Angle
14-20	93	9.5	Angle
15-21	110	9.5	Angle
18-20	220	9.7	Angle

3.2.3 Off-street parking data

The provision of off-street parking in Kandy is dominated by the Kandy City multi storied car park that is presently managed by the Kandy Municipal Council. This facility has space for 850 vehicles.

Off-street parking data were collected from the off-street parking records from the Kandy Municipality Council for the same date of on-street parking survey conducted (Appendix 3). The Table 3.5 represents the summary of data collected from 7:00 am to 19:00 pm.

Table 3.5 - Summary of off-street parking survey

Time Interval	No of Parked vehicles
7.00-7.30	110
7.30-8.00	205
8.00-8.30	299
8.30-9.00	418
9.00-9.30	544
9.30-10.00	703
10.00-10.30	836
10.30-11.00	932
11.00-11.30	1054
11.30-12.00	1039
12.00-12.30	1054
12.30-13.00	1056
13.00-13.30	1013
13.30-14.00	955
14.00-14.30	921
14.30-15.00	923
15.00-15.30	892
15.30-16.00	850
16.00-16.30	861
16.30-17.00	814
17.00-17.30	786
17.30-18.00	700
18.00-18.30	578
18.30-19.00	462

3.2.4 Turning movement data

Turning movement data were collected by Planning Division, Road development Authority and turning movement for each junction shown by Appendix 6. Data were used to find the traffic flow in and out of the Kandy city.

4 DATA ANALYSIS

In this chapter, data gathered described in methodology was analyzed using different analysis methods such as statistical analysis, spatial analysis etc. to identified the effect of on street parking on-traffic speed, factors that influence drivers on parking, to identify the relationship between the on-street and off-street parking with the traffic volume, to find the demand for two types of parking (off-street and on-street parking).

4.1 Effect of on-street parking on Traffic speed

Field survey data carried out on research area were used to find the level of parking in each street segment. Since, individual parking space is not clearly defined and following criteria is used to find the level of parking.

Table 4.1 - Standard parking widths and lengths

Vehicle Type	Angle width (m)	Parallel Length (m)
Motor Cycle	2.1	2.5
Three wheelers	2.1	2.5
Car	2.4	5.5
Van	2.4	5.5
Medium Buses	3.6	12
Large Buses	3.6	12
Small Lorries	3.6	12
Two axle lorries/ truck with 6 wheels (weight <8.5 tons)	3.6	12
Two axle lorries/ truck with 6 wheels (weight >8.5 tons)	3.6	12
Three Axle vehicles	3.3	20

Three Axle Articulated vehicles	3.3	19
Four Axle Articulated vehicles	3.3	19
Five Axle Articulated vehicles	3.3	19
Six Axle Articulated vehicles	3.3	19
Four wheel tractor	3.3	19

For the angle parking angle 60^0 were used. Projected width of each vehicle was calculated according to the angle width of vehicle type given in Table 4.1 as shown in Figure 4.1 below.

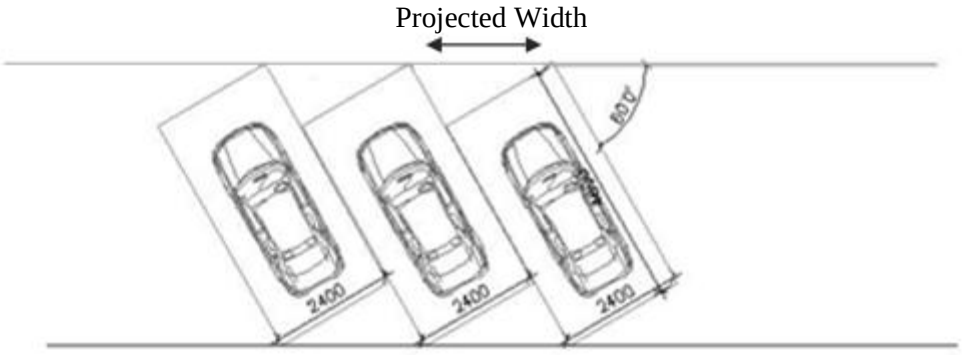

Figure 4.1: Projected width of angle parking

For parallel parking length of each vehicle were found according to the parallel length of vehicle type given in Table 4.1 as shown in Figure 4.2 below.

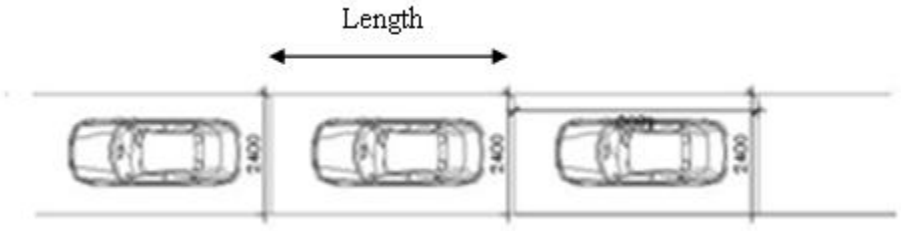

Figure 4.2 : Length of parallel parking

Following steps were followed to find the parking level of each segment

1. The total parking length for each segment for angle parking = total projected width of vehicle
2. The total parking length for each segment for parallel parking = total length of vehicle
3. $$\text{Parking level} = \frac{\left\{\begin{array}{l}\text{Total projected parking width for angle parking and} \\ \text{Total Length of vehicles for parallel parking}\end{array}\right\}}{\text{Total segment length}} * 100$$

Parking level for each selected street segment for speed analysis is given in Appendix 4. Real time speed data in Appendix 2 and parking level calculated in Appendix 4 was used to find the effect for traffic due to the on-street parking in each selected street segment. Table 4.2 to Table 4.13 represents parking level and speed data of each segment. Figure 4.3 to Figure 4.14 represents the relationship of speed with the parking level.

i) Street segment 2-9

Table 4.2 - Speed results for street segment 2-9

Parking Level %	8	13	21	25	29	31	37	38	40	40	40	42
Speed (km/h)	7.2	7.3	7.3	6.8	6.8	6.5	6.8	6.4	6.8	6.6	6.8	6.6
Parking Level %	43	43	44	45	46	47	48	49	54	55	57	65
Speed (km/h)	6.6	6.7	6.8	6.7	6.8	7.2	6.7	6.9	6.7	6.9	6.8	7.1

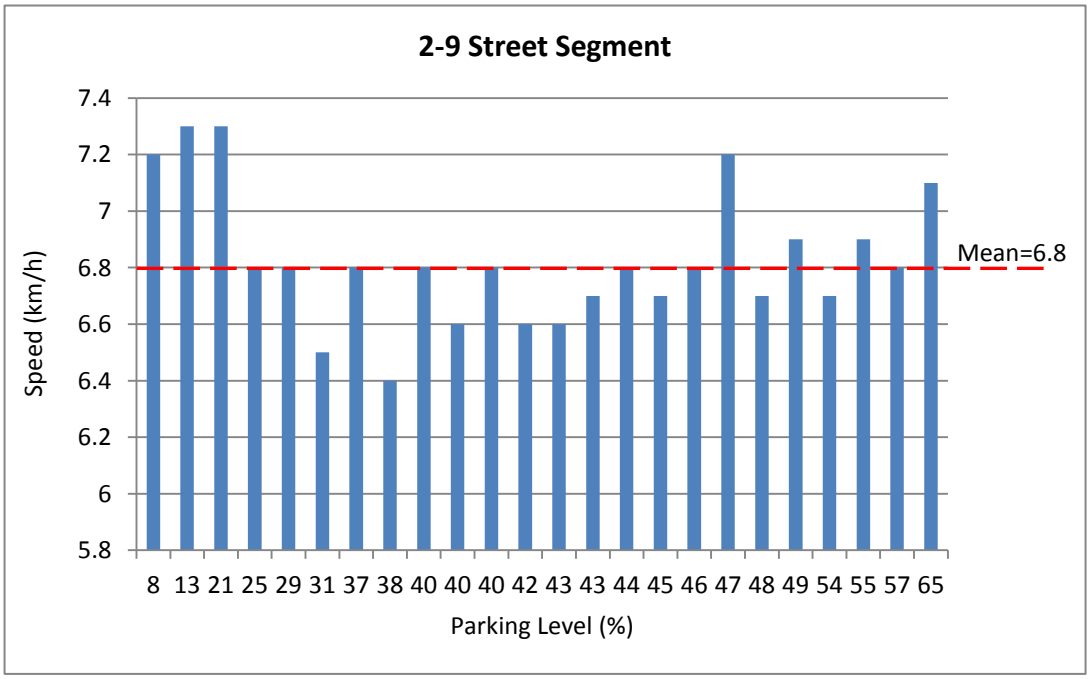

Figure 4.3 : Traffic speed and speed results for street segment 2-9

ii) Street segment 7-8

Table 4.3 - Speed results for street segment 7-8

Parking Level %	50	54	75	96	123	138	119	154	147	130	135	136
Speed (km/h)	5.9	5.9	5.8	5.9	5.7	5.6	5.7	5.6	5.5	5.5	5.6	5.5
Parking Level %	130	134	148	138	144	124	161	147	164	103	83	93
Speed (km/h)	5.5	5.6	5.4	5.4	5.6	5.5	5.5	5.6	5.5	5.7	5.8	5.8

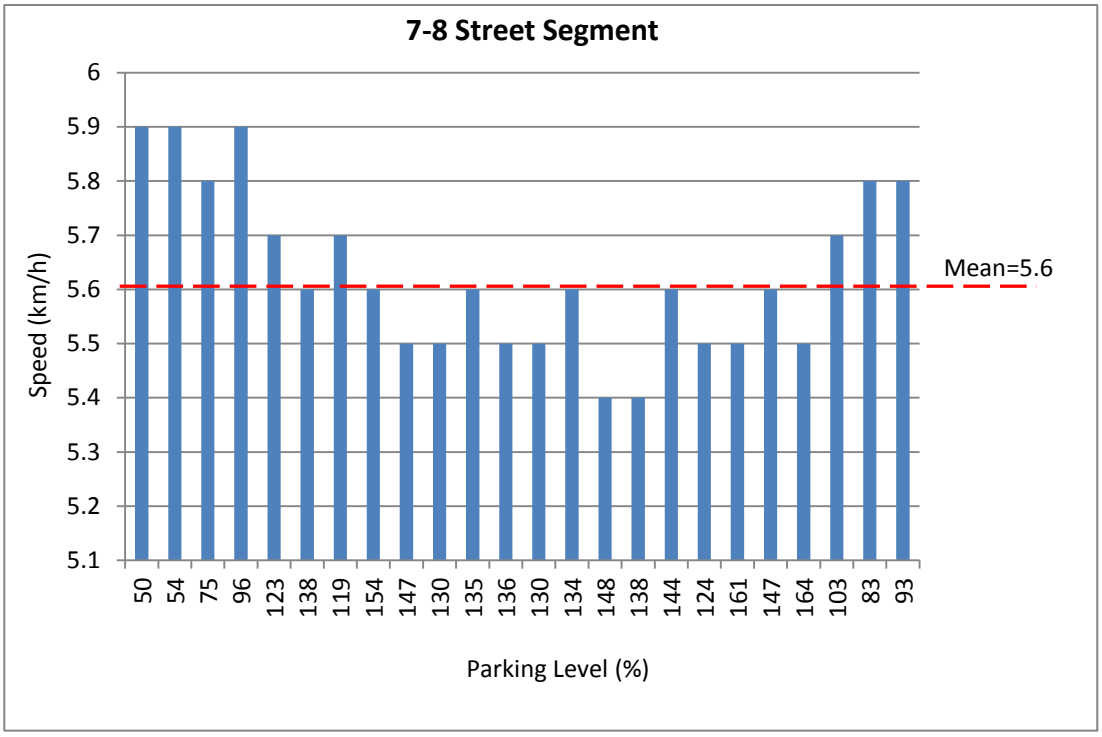

Figure 4.4 : Traffic speed and speed results for street segment 7-8

iii) Street segment 8-9

Table 4.4 - Speed results for street segment 8-9

Parking Level %	84	144	163	26	80	99	90	101	97	124	122	137
Speed (km/h)	5.9	5.7	5.8	6.1	6.0	6.0	5.9	5.9	5.8	5.8	5.8	5.8
Parking Level %	119	106	16	92	50	90	89	131	98	132	104	44
Speed (km/h)	5.8	5.9	6.3	6.0	6.0	5.9	5.8	5.8	5.8	5.7	5.9	6.1

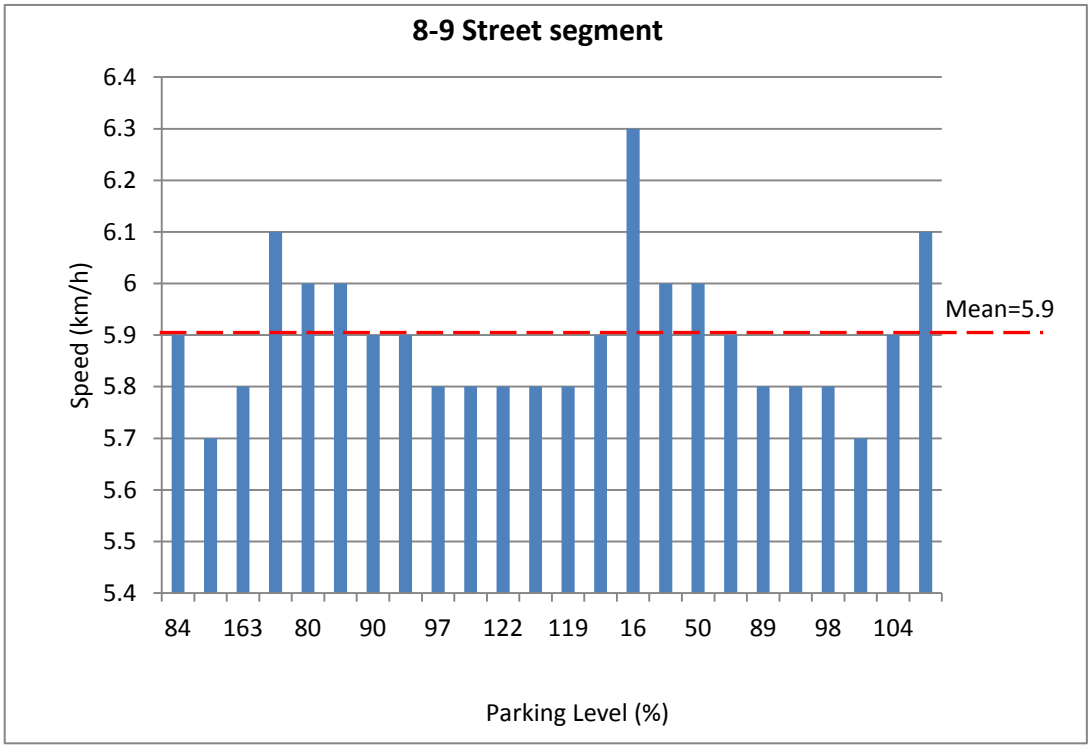

Figure 4.5 : Traffic speed and speed results for street segment 8-9

iv) Street segment 7-13

Table 4.5 - Speed results for street segment 7-13

Parking Level %	60	85	55	82	115	101	93	94	92	98	79	116
Speed (km/h)	5.7	5.1	5.8	5.1	4.9	5.0	5.2	5.1	5.1	5.1	5.2	4.9
Parking Level %	88	102	87	93	94	91	94	104	72	86	106	68
Speed (km/h)	5.3	4.9	5.2	5.2	5.1	5.2	5.1	4.9	5.3	5.2	4.8	5.6

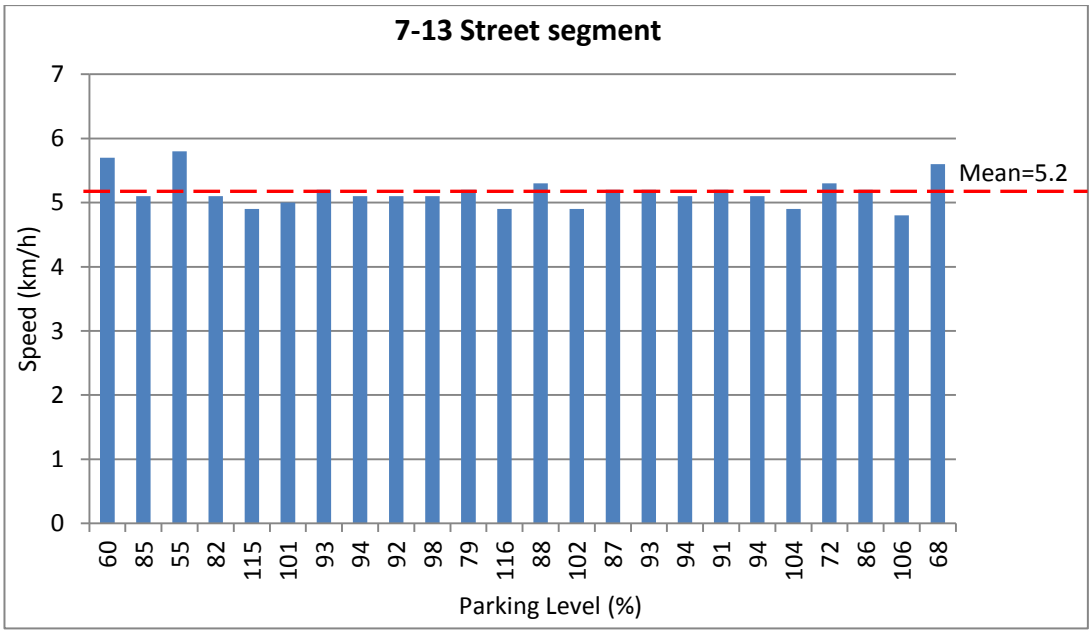

Figure 4.6: Traffic speed and speed results for street segment 7-13

v) Street segment 8-15

Table 4.6 - Speed results for street segment 8-15

Parking Level %	36	76	68	74	6	75	76	5	81	93	83	89
Speed (km/h)	6.8	6.5	6.7	6.4	6.9	6.5	6.5	6.9	6.4	6.2	6.4	6.3
Parking Level %	89	87	86	90	83	93	82	75	93	92	67	55
Speed (km/h)	6.3	6.3	6.4	6.1	6.4	6.2	6.4	6.5	6.3	6.2	6.6	6.8

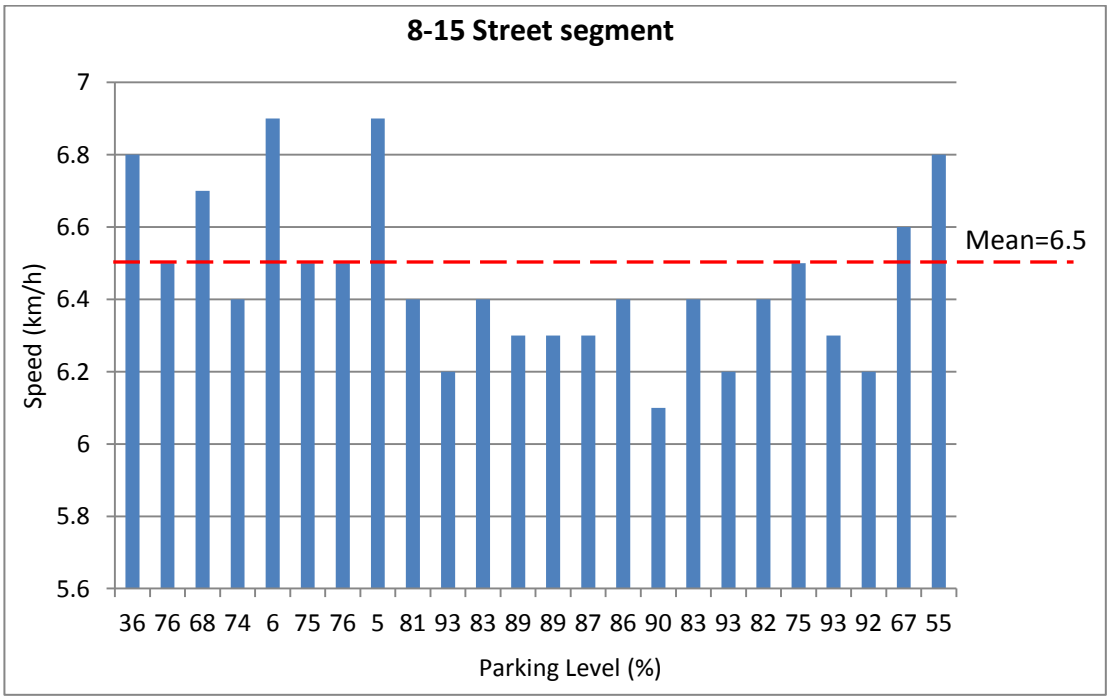

Figure 4.7: Traffic speed and speed results for street segment 8-15

vi) Street segment 12-13

Table 4.7 - Speed results for street segment 12-13

Parking Level %	74	62	36	80	90	102	103	97	103	89	76	50
Speed (km/h)	5.5	5.5	5.8	5.0	4.9	4.9	4.8	4.8	4.9	4.9	4.9	5.6
Parking Level %	101	102	89	101	91	99	91	90	100	101	101	99
Speed (km/h)	4.9	4.8	4.9	4.8	4.9	4.9	4.9	5.0	4.8	4.9	4.8	4.9

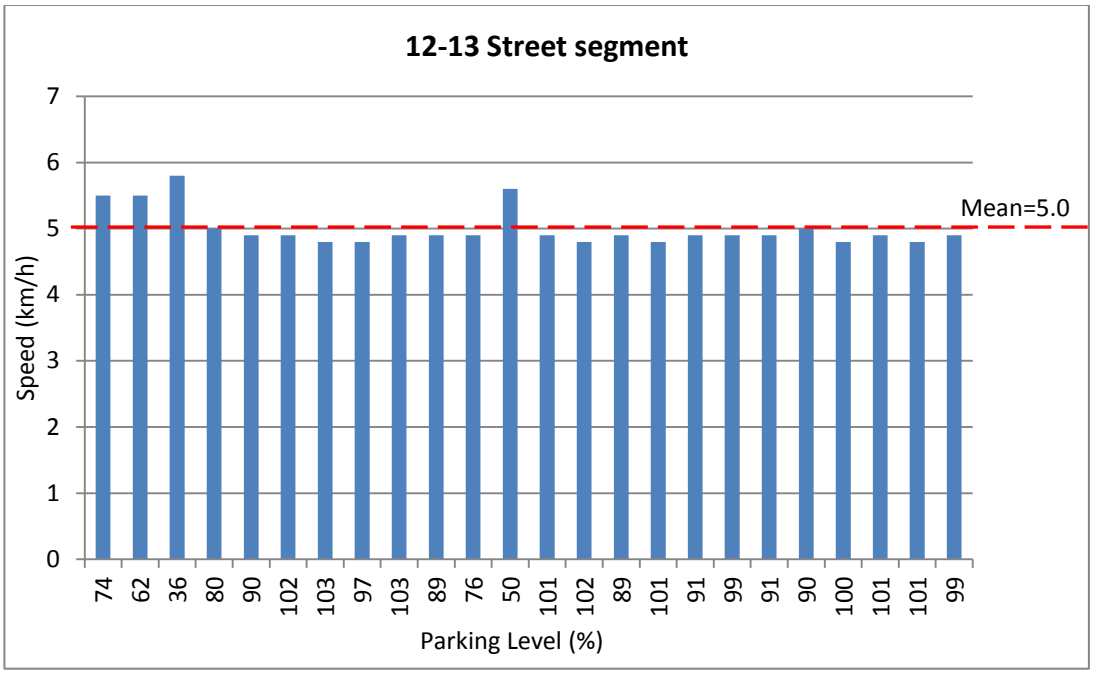

Figure 4.8 : Traffic speed and speed results for street segment 12-13

vii) Street segment 13-14

Table 4.8 - Speed results for street segment 13-14

Parking Level %	60	75	85	98	98	99	98	98	99	99	99	100
Speed (km/h)	5.7	5.5	5.4	5.2	5.3	5.2	5.2	5.2	5.3	5.2	5.2	5.1
Parking Level %	99	75	80	99	69	75	75	81	97	99	77	51
Speed (km/h)	5.3	5.4	5.4	5.2	5.6	5.4	5.3	5.3	5.2	5.2	5.3	5.7

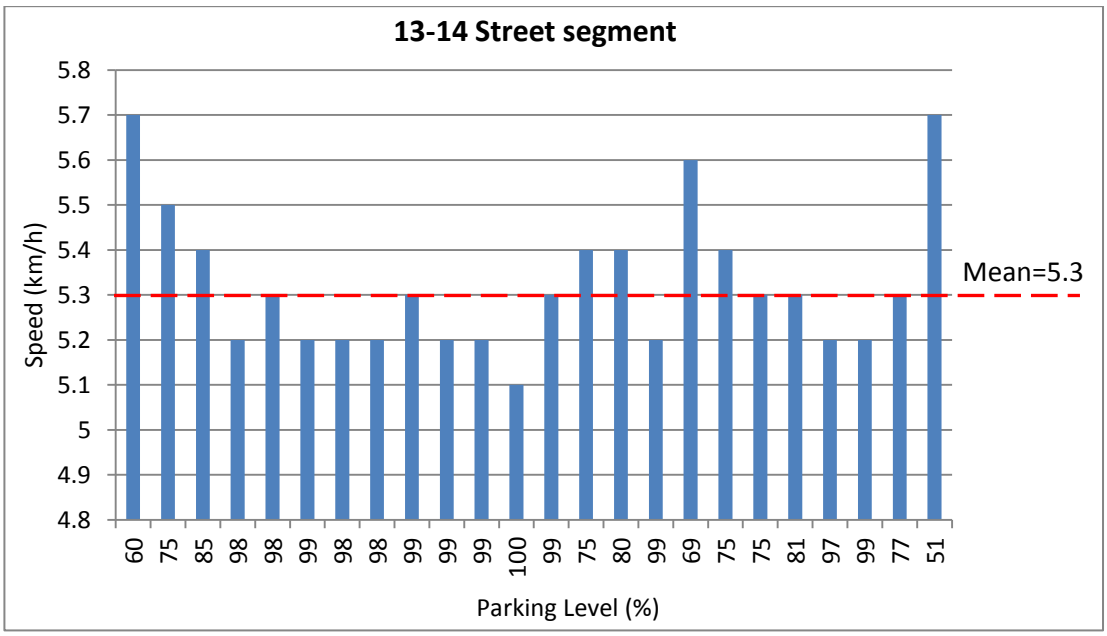

Figure 4.9 : Traffic speed and speed results for street segment 13-14

viii) Street segment 14-15

Table 4.9 - Speed results for street segment 14-15

Parking Level %	27	27	46	30	13	49	56	11	52	57	12	77
Speed (km/h)	6.0	5.9	5.8	5.9	6.0	5.8	5.7	6.0	5.6	5.7	6.0	5.5
Parking Level %	59	51	35	64	48	59	57	56	38	51	33	29
Speed (km/h)	5.6	5.7	5.9	5.5	5.8	5.6	5.7	5.7	5.9	5.7	5.8	5.9

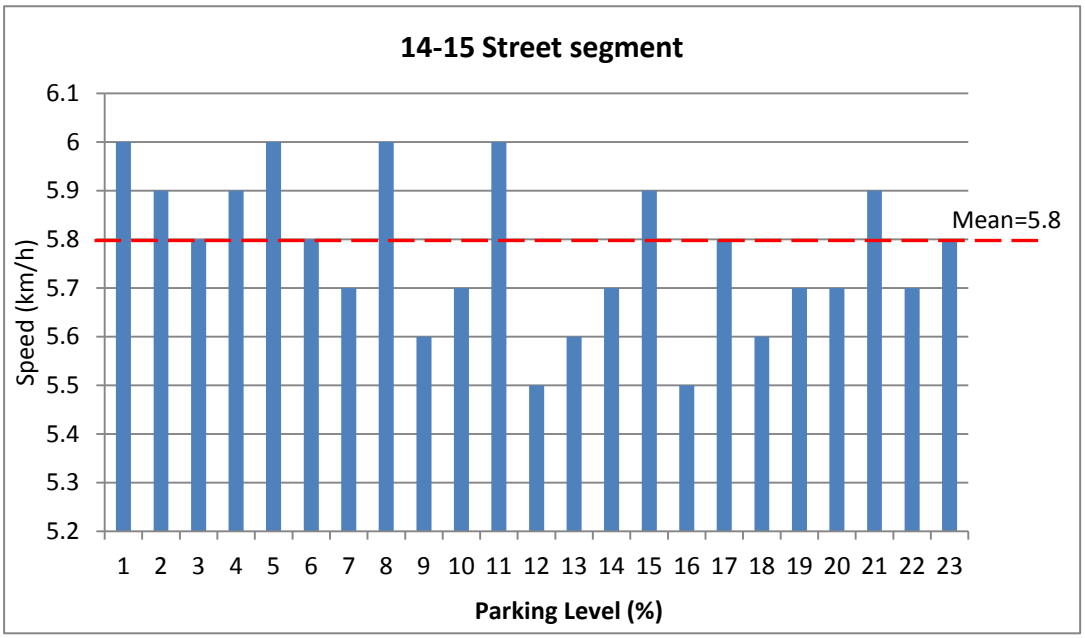

Figure 4.10 : Traffic speed and speed results for street segment 14-15

ix) Street segment 13-19

Table 4.10 - Speed results for street segment 13-19

Parking Level %	69	86	97	99	99	100	101	99	100	100	101	101
Speed (km/h)	5.7	5.4	5.1	5.2	5.1	5.1	5.1	5.2	5.1	5.2	5.1	5.1
Parking Level %	101	86	92	99	79	86	86	93	99	93	88	58
Speed (km/h)	5.2	5.3	5.2	5.2	5.3	5.2	5.2	5.2	5.1	5.1	5.2	5.8

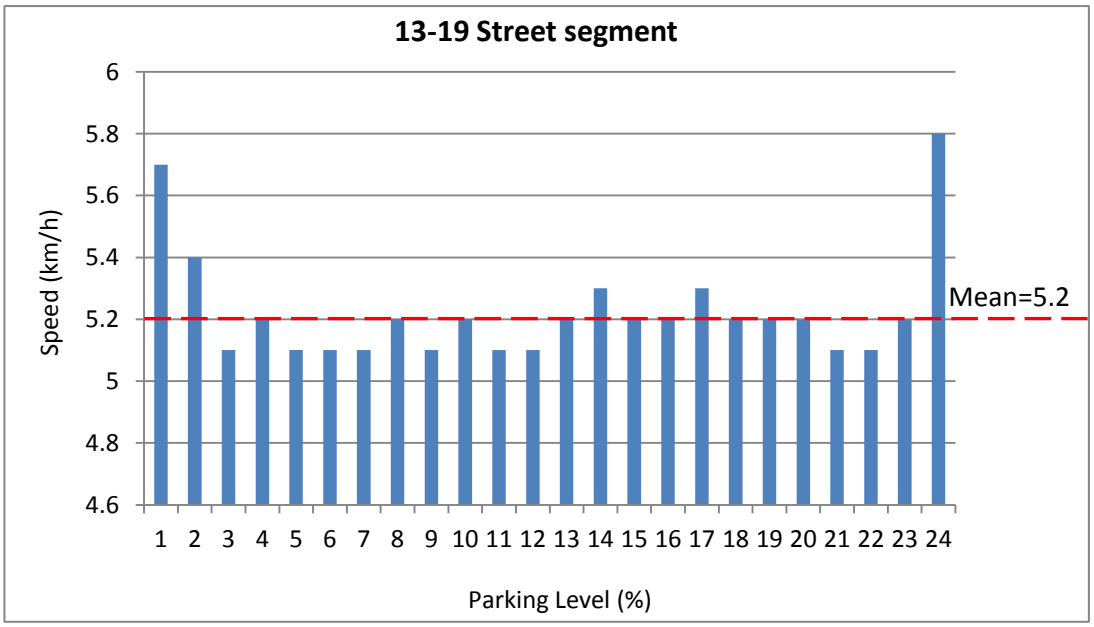

Figure 4.11: Traffic speed and speed results for street segment 13-19

x) Street segment 14-20

Table 4.11 - Speed results for street segment 14-20

Parking Level %	88	77	78	68	80	82	87	75	77	87	77	87
Speed (km/h)	6.2	6.3	6.3	6.5	6.2	6.3	6.3	6.4	6.4	6.3	6.3	6.3
Parking Level %	89	97	59	55	83	79	81	53	77	48	47	57
Speed (km/h)	6.3	6.0	6.6	6.6	6.3	6.4	6.4	6.7	6.4	6.6	6.5	6.6

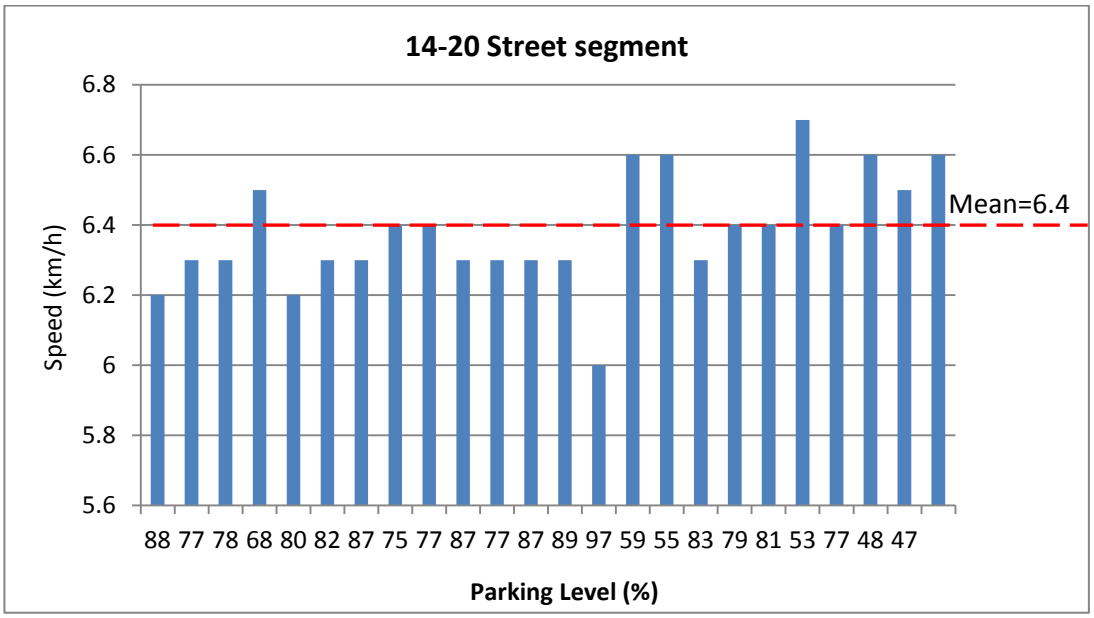

Figure 4.12 : Traffic speed and speed results for street segment 14-20

xi) Street segment 15-21

Table 4.12 - Speed results for street segment 15-21

Parking Level %	68	52	56	91	83	68	74	90	45	96	52	52
Speed (km/h)	6.5	6.7	6.6	6.2	6.4	6.5	6.4	6.1	6.7	6.2	6.6	6.6
Parking Level %	97	98	85	74	88	100	75	64	63	92	94	96
Speed (km/h)	6.1	6.2	6.2	6.5	6.1	6.0	6.5	6.6	6.6	6.0	6.2	6.1

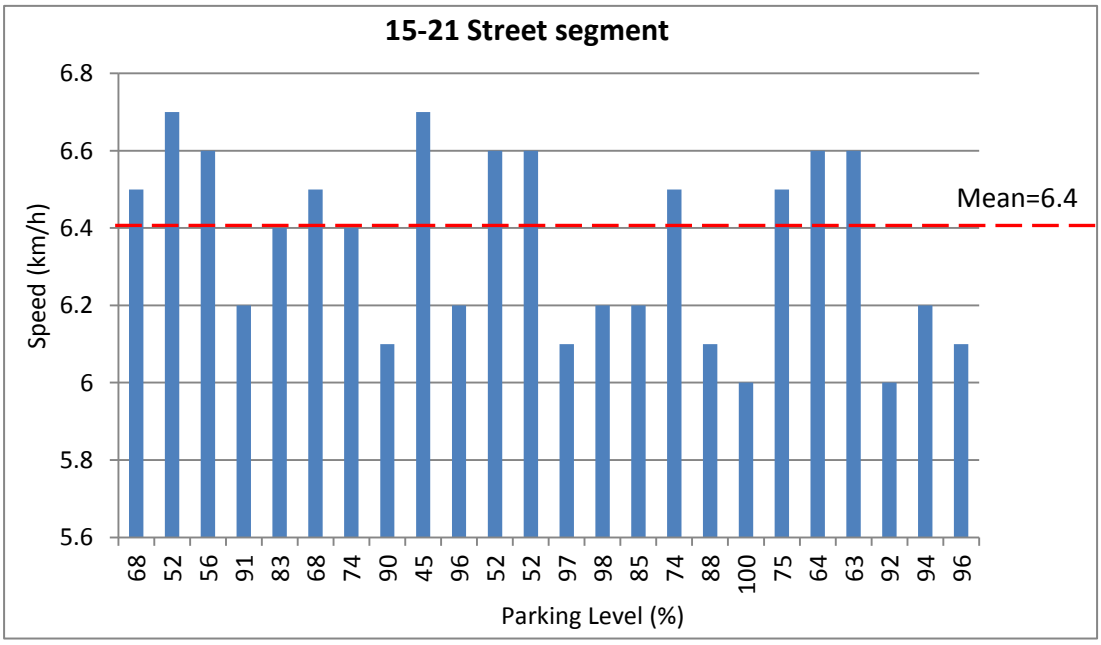

Figure 4.13 : Traffic speed and speed results for street segment 15-21

xii) Street segment 18-20

Table 4.13 - Speed results for street segment 18-20

Parking Level %	30	33	40	44	56	64	69	60	57	67	60	57
Speed (km/h)	6.8	6.7	6.8	6.7	6.5	6.6	6.7	6.6	6.7	6.5	6.4	6.6
Parking Level %	63	53	79	66	63	56	50	55	46	43	22	16
Speed (km/h)	6.4	6.7	6.4	6.5	6.6	6.5	6.5	6.5	6.7	6.8	6.8	6.8

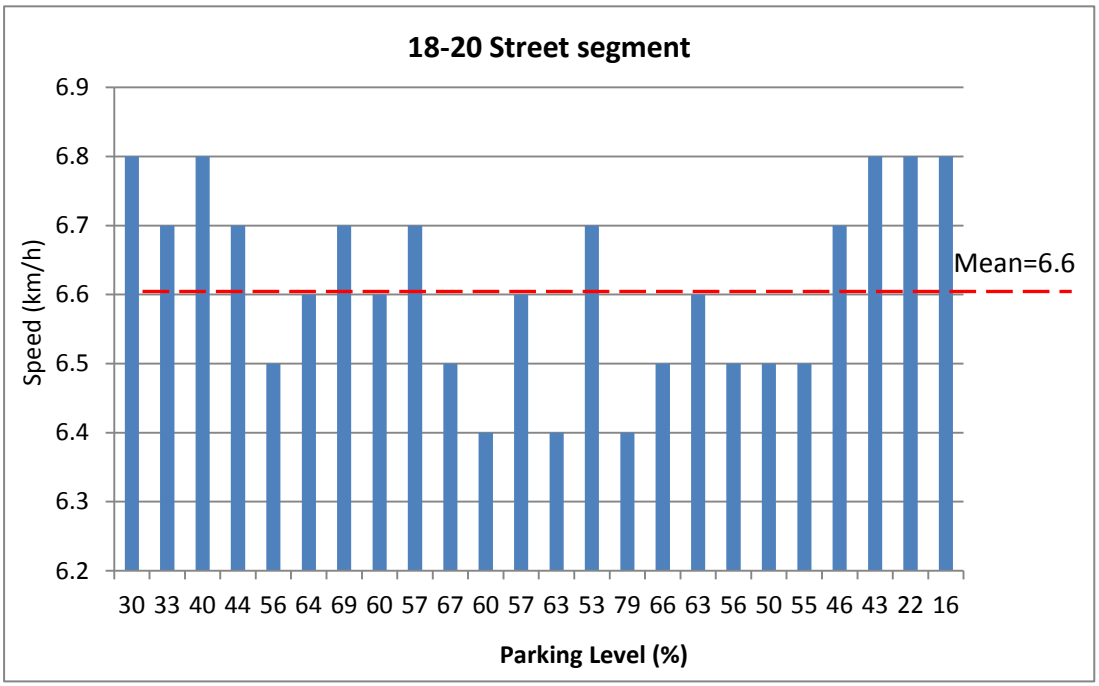

Figure 4.14 : Traffic speed and speed results for street segment 18-20

The Table 4.14 below shows the mean, max, min and standard deviation of speed in each street segment.

Table 4.14 - Speed results for all segments with parking level

Segment	Width (m)	Min. Speed (Km/h)	Max. Speed (Km/h)	Mean Speed (Km/h)	S.D of Speed
2-9	9.9	6.4	7.3	6.8	0.24
7-8	9	5.4	5.9	5.6	0.15
8-9	9	5.7	6.3	5.9	0.14
7-13	9	4.8	5.8	5.2	0.25
8-15	9.5	6.1	6.9	6.5	0.22
12-13	9	4.8	5.8	5.0	0.28
13-14	9	5.1	5.7	5.3	0.16
14-15	9	5.5	6	5.8	0.16
13-19	9	5.1	5.8	5.2	0.18
14-20	9.5	6	6.7	6.4	0.16
15-21	9.5	6	6.7	6.4	0.23
18-20	9.7	6.4	6.8	6.6	0.14

Figure 4.3 to Figure 4.14 shows that traffic speeds generally fell gradually with an increase in parking levels. Narrow width streets have the minimum and wider streets have the higher mean speed.

Comparison of Sites

Street segments were grouped in to three groups as depending on their widths as shown in table 4.15 below.

Table 4.15 – Street segment groups with the width of the segment

Street segment width (m)	**Segment Group**
9	Narrow
9.5,9.7	Medium
9.9	Wider

A graph combining all the results according to the categorization in Table 4.15 is shown in Figure 4.15 below and it indicates that speed fell with an increase in the parking level. This is evident in all parking categories.

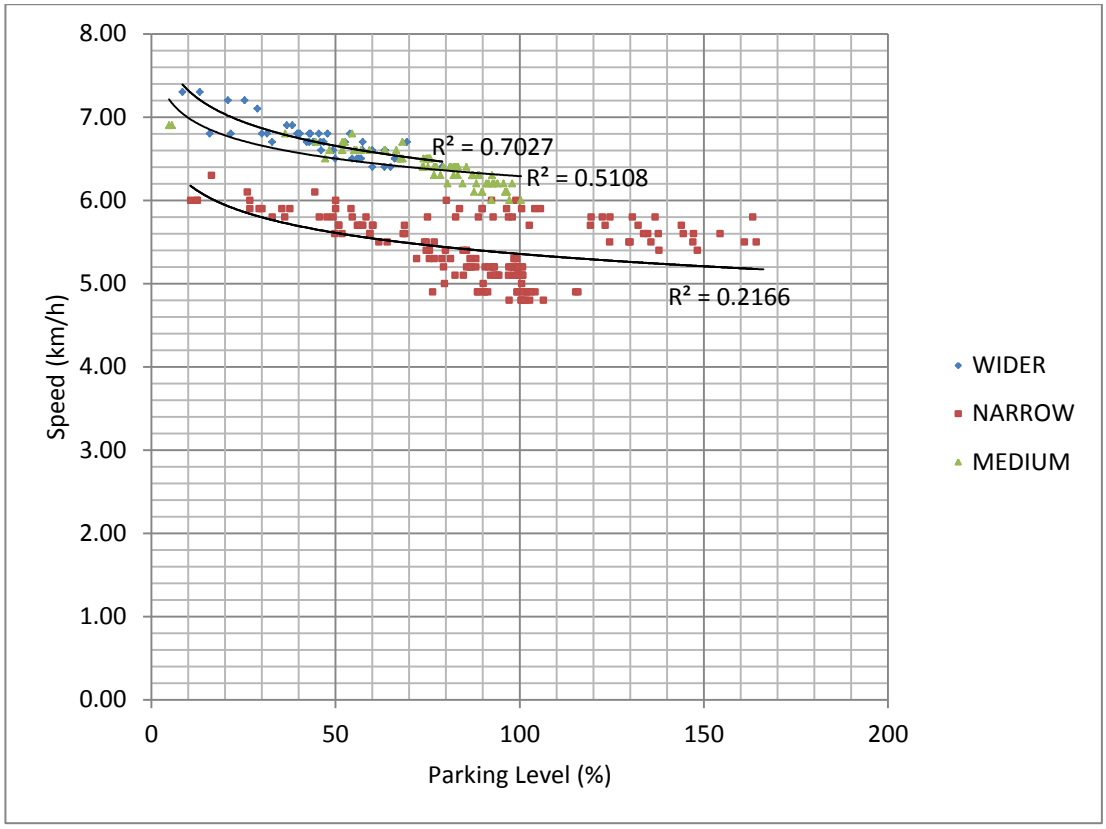

Figure 4.15: Variation of speed with parking level

According to the above Figure 4.15 can conclude that the degree of correlation value is not good for narrow streets ($R^2 = 0.2166$) and it gives clear picture of that on-street parking tends to slow down speeding vehicles. In narrow streets, beyond the parking level 170 the speed reduction level value turns to a steady value. Previous research has suggested that crash rates tend to decrease as the speed decreases (e.g. Garber & Ehrhart 2000, Fildes & Lee 1993). Therefore, it is give a clear idea of increasing on-street parking can make a positive effect for safety. This needs to be considered in conjunction with other evidence suggesting that the obstructive effect of parking causes safety concerns (e.g. Sisiopiku 2001).

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4.2 Comparison between On-street and Off-street parking in Kandy City

The specific objectives of this analysis are:

- Determine relationship between on-street and off-street parking in Kandy city.
- The locations and time which the on-street parking demand is high.
- Determine the range of walking distances, how far people are willing to walk to and from a parking location of their vehicle. (Between parked vehicle and primary or first destination).

Total number of vehicles on-street and off-street parking is given by the following table.

Table 4.16 – On-street and Off-street parking data with time

Parking Area / Time Interval	Off-street (Nos)	On-street (Nos)
7.00-7.30	110	615
7.30-8.00	205	699
8.00-8.30	299	720
8.30-9.00	418	805
9.00-9.30	544	885
9.30-10.00	703	1026
10.00-10.30	836	1082
10.30-11.00	932	995
11.00-11.30	1054	1160
11.30-12.00	1039	1317
12.00-12.30	1054	1155
12.30-13.00	1056	1230
13.00-13.30	1013	1145
13.30-14.00	955	1010
14.00-14.30	921	1288

14.30-15.00	923	1001
15.00-15.30	892	982
15.30-16.00	850	1061
16.00-16.30	861	1355
16.30-17.00	814	1021
17.00-17.30	786	1043
17.30-18.00	700	1010
18.00-18.30	578	891
18.30-19.00	462	710

The graphical representation of data given in Table 4.16 is shown in Figure 4.16 below.

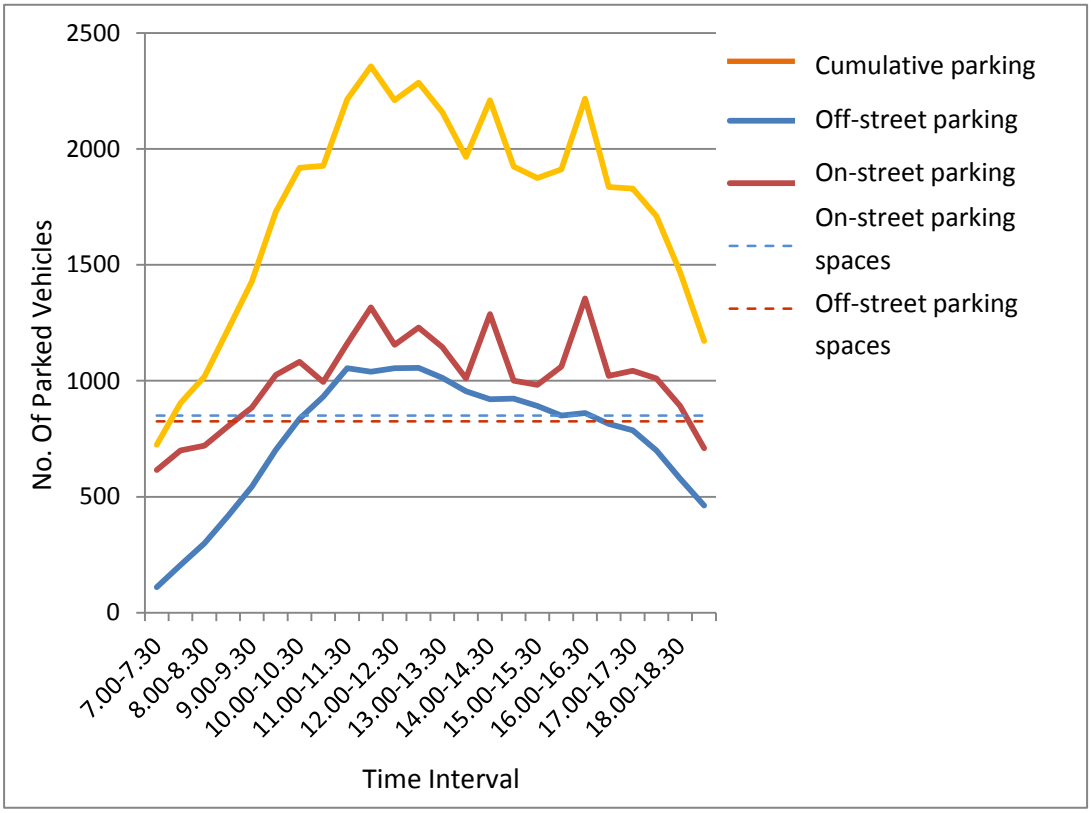

Figure 4.16 : On street and Off street parking with time

Each curve represents the pattern of parking demand over the day. The "Cumulative" line in the chart represents the aggregate pattern of parking demand that would be formed by these two types of parking types. Thus, while each type form different parking types peak parking demand occur at different times of the day. According to the graph in figure 4.15, the on street and off street parking have nearly similar pattern except some gradual increase and decreases of variations in on street parking. The time periods 9.00-9.30 to 18.30-19.00 in on street parking demand and 10.00-10.30 to 16.00-16.30 in off street parking demand was higher than the maximum parking capacity of 825 in on street and 850 in off street parking. The reason of that is the sharing a one parking area is happens in several times in the study time intervals.

4.2.1 Spatial analysis of parking data

The graphic analysis of parking data and spatial analysis was done to get more idea about the demand changes of two parking types with time. Moreover, the areas which have the highest parking demand with time and distances to those areas give from this analysis. The relationship between "where people park" and "where they wish to go" cannot be accommodated properly by collected data and general idea about their destination is given according to the land use pattern around the parking area.

The on street data for each segment in the study area and off street data were grouped in to six time intervals as given in Appendix 5. Following figures represent the distribution of on street parking over seven time intervals. Buffer zones for the spatial analysis were selected in 200m distance intervals from the off street car park in the study area. The segment lines represent the parking levels to the respective time intervals.

i) Time interval 7:00 – 9:00

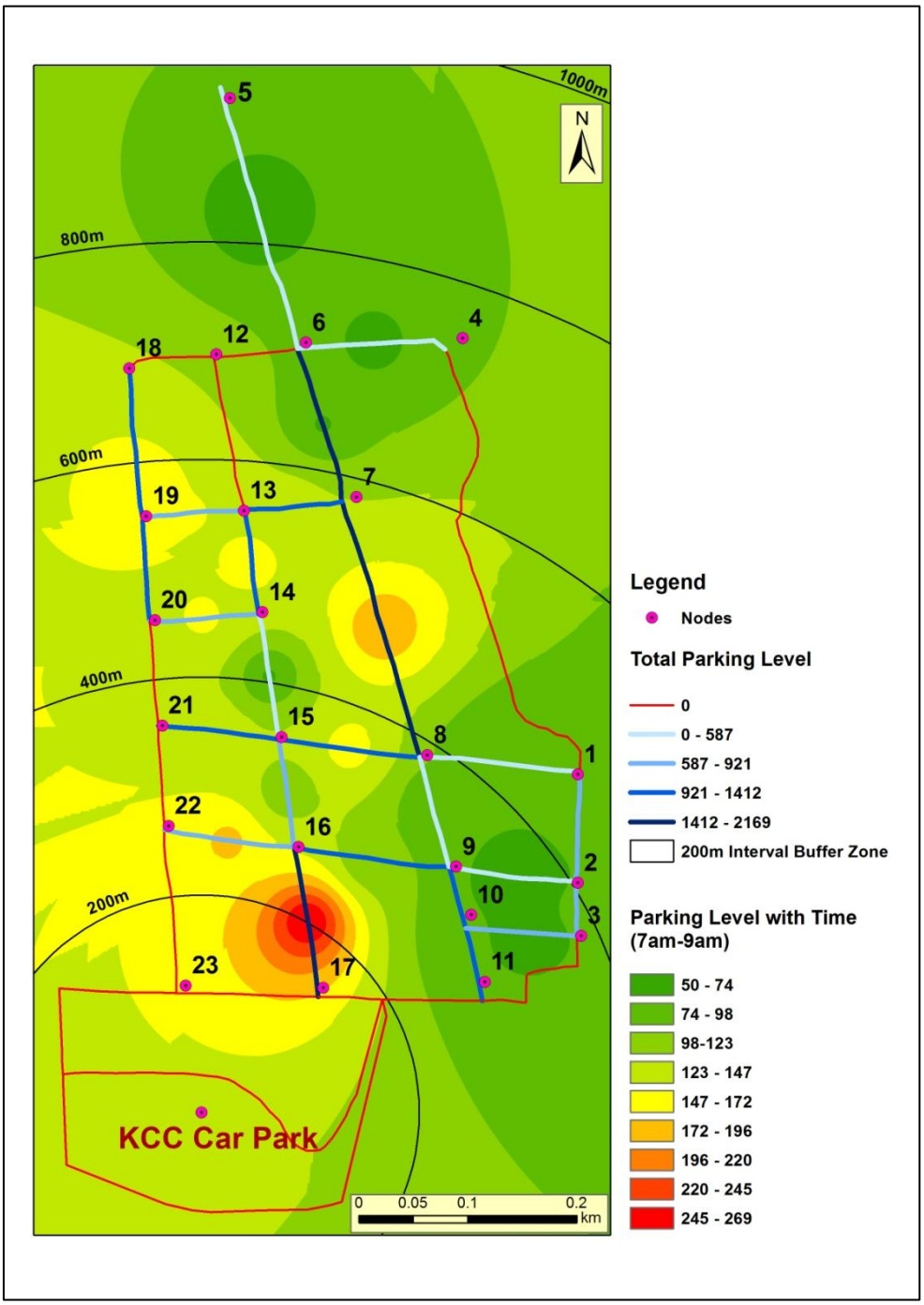

Figure 4.17: Graphical representation of On street parking in 7:00-9:00

According to the above it shows that segment 16-17 in buffer zone 200m has the highest demand of parking and segment 7-8 in buffer zone 500m has also some attraction for parking.

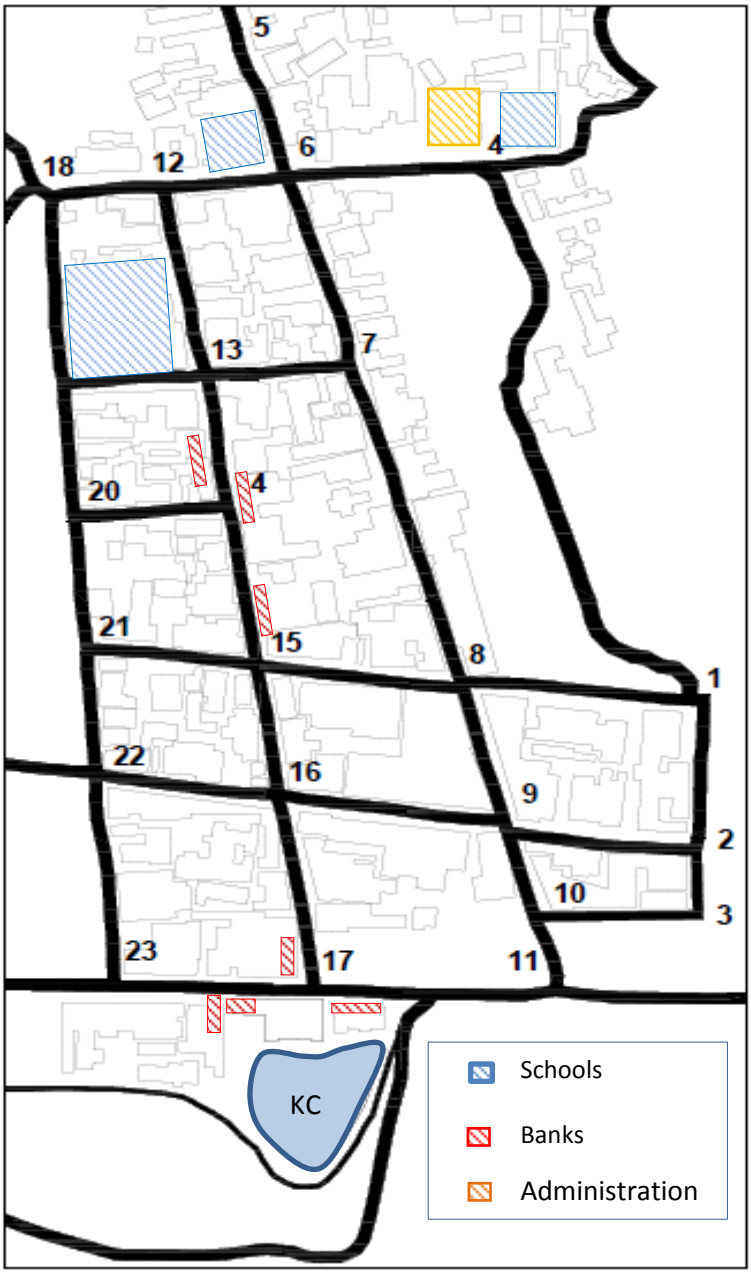

Figure 4.18: Main attraction points near the highest demand of on street parking in 7:00-9:00

As shown in the Figure 4.17 mainly banks are located along the 23-17 and 17-11 segments and these segments are prohibited for on street parking. Therefore, as per the results can conclude that people are parking on 16-17 and 22-16 segments mainly to reach their destination in 23-17 and 17-11 segments.

Segment 7-8 is very close to the Trinity Collage primary school and vehicles are prohibited for parking on 6-4 segment in school hours. Therefore, people may tend to park their vehicles near the closest parking availability point.

Segments 18-19, 13-14, 20-14 and 15-8 has growing attraction for parking in this time interval. 18-19 is close to the Kandy District Secretariat and other segments are located around the commercial areas.

Also, from the south direction of the town, vehicles are entering from 23 and 17 nodes and along the 23-21 segments are prohibited for parking. Therefore, at the entering points 16-17 segment may catches as the main parking point.

Table 4.17 - On street and Off street parking data 7:00-9:00

	Time	**On street**	**Off street**
Time Interval 7:00-9:00	7:00	615 (825)	110 (850)
	9:00	805 (825)	418 (850)

Demand for on street parking is starting from a higher value (615 Nos) and it reaches near to the available capacity (825 Nos) of on street parking at the start of the day within very short period. At the same time interval vehicles are tends to park off street is in very lower value (110 Nos) and the parking values are not close to the available off street capacity (850 Nos), but increases in gradually with time.

According to the above analysis can conclude, at the start of the day the streets are free and parking availability of on street is very high. Therefore, people may have a feeling that parking their vehicles in an on street space available near to their

destination is better than parking their vehicles off street car park and walking to their destination. Moreover, the highest demand for the parking in 16-17 segment give more transparent results for the above conclusion, because that segment is very close to the car park and only 200m away from the Off street park.

ii) Time interval 9:00 – 11:00

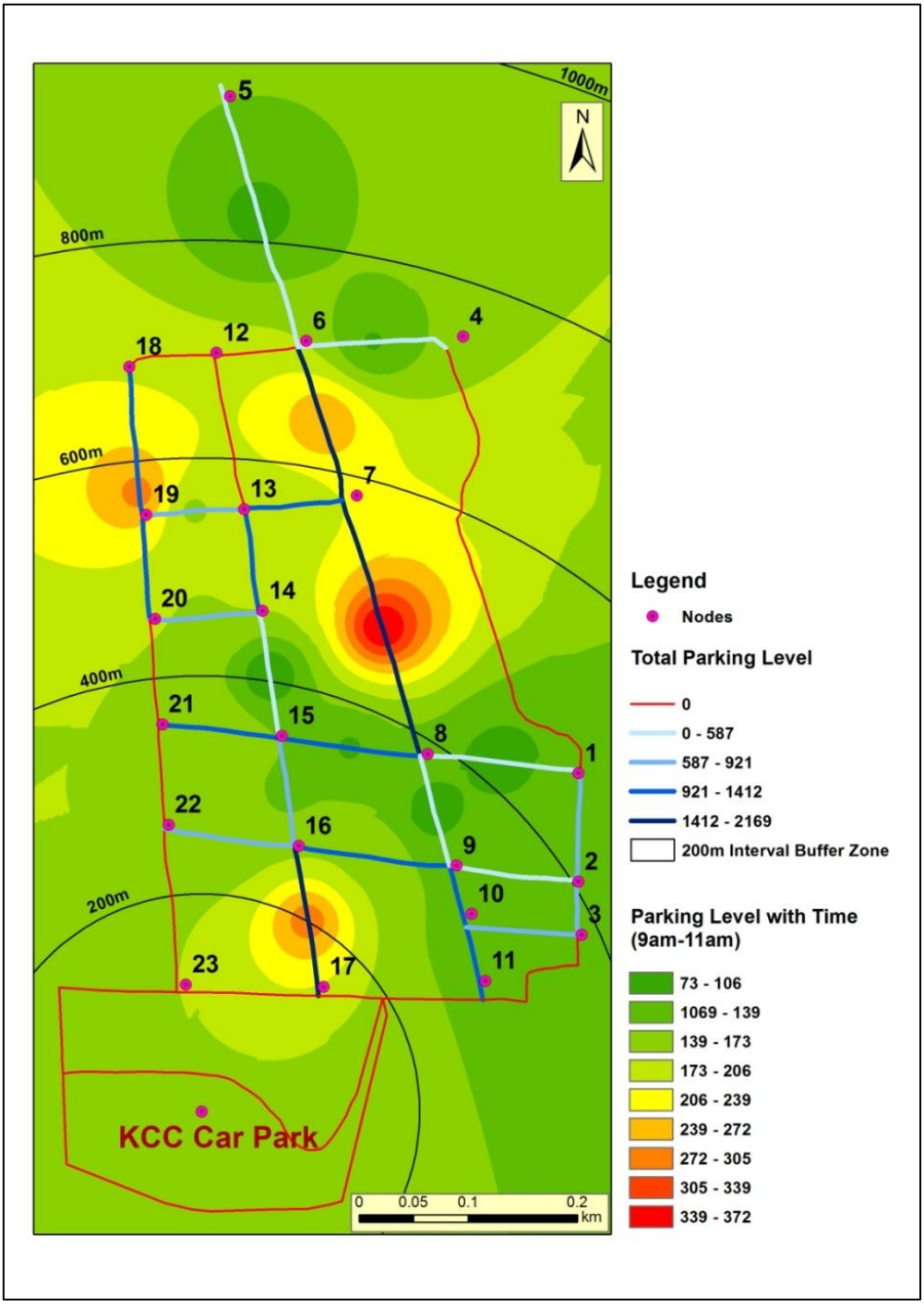

Figure 4.19: Graphical representation of On- street parking in 9:00-11:00

The above results shows that parking demand for the segment 7-8 in buffer zone 500m has the highest demand and clearly can see the parking demand for 18-19 and 6-7 segments are increased and segment 16-17 is reduced in this time period from the demand in 7:00 – 9:00.

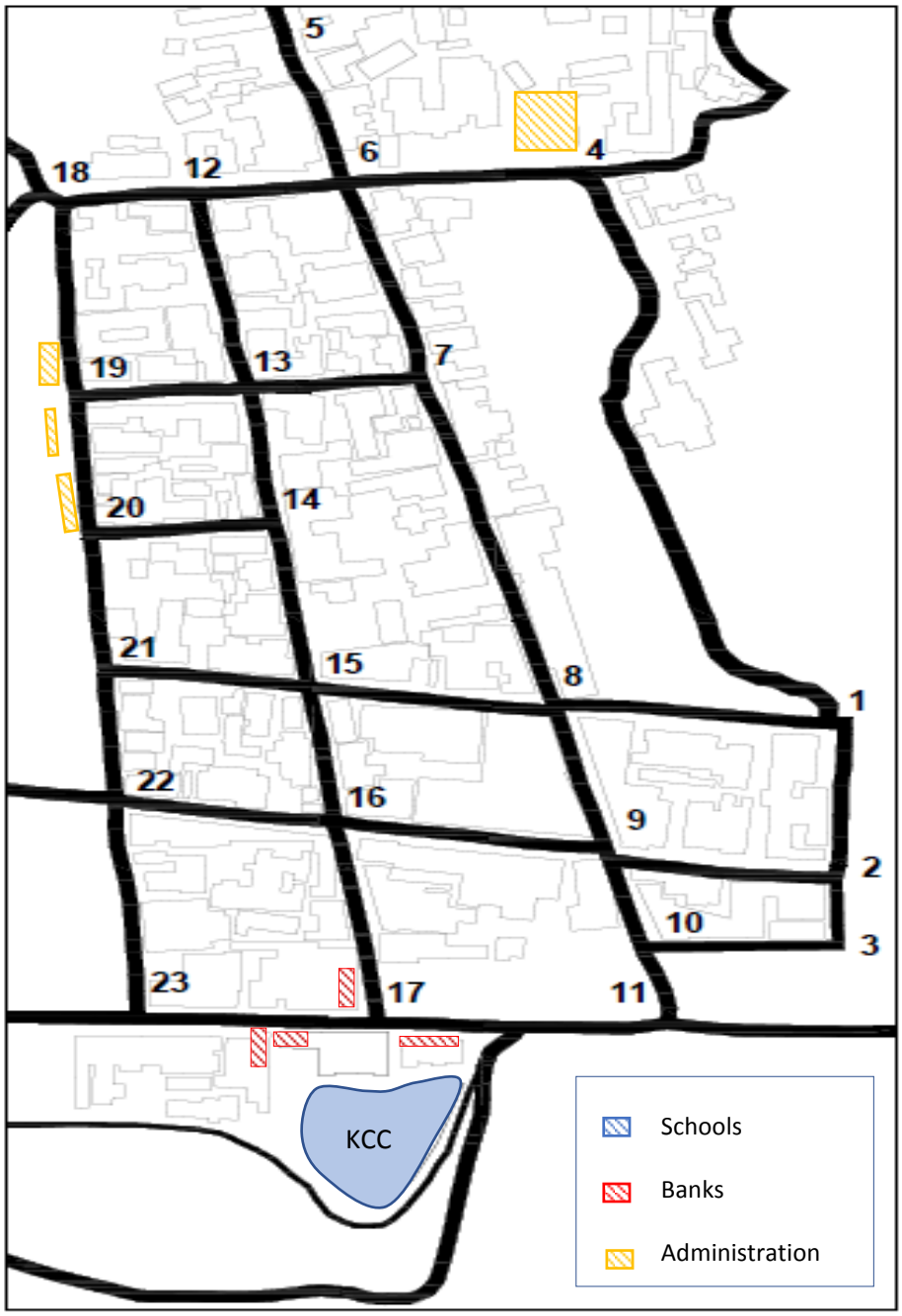

Figure 4.20 : Main attraction points near the highest demand of on street parking in 9:00-11:00

As shown in the Figure 4.19 administration offices such as Kandy District Secretariat, District Labor and Government office are in segment 18-19 and this may be the reason of increasing the parking demand of this segment gradually in this time period. Also 6-7 and 7-8 is close to the Kandy Municipal Council and this may be the reason of the demand is in a higher value in these segments.

Table 4.18 - On street and Off street parking data 9:00-11:00

	Time	**On street**	**Off street**
Time Interval 9:00-11:00	9:00	885 (825)	544 (850)
	11:00	995 (825)	932 (850)

At the starting of this time period demand for on street parking has reached to the maximum value of the available capacity (825 Nos). The demand is greater than the available capacity due to the space sharing and space sharing is more at 11:00 (995). At the same time period demand for parking in off-street park is also reached the available off-street capacity (850 Nos).

According to the above analysis can conclude that on street parking demand higher segments are 7-8, 18-19 and 6-7. These segments have the highest distance (buffer zone 500m, 600m) from the off street car park. Therefore, people may park their vehicles near to their destination to reduce the walking distance to their destination (Administration locations).

iii) Time interval 11:00 – 13:00

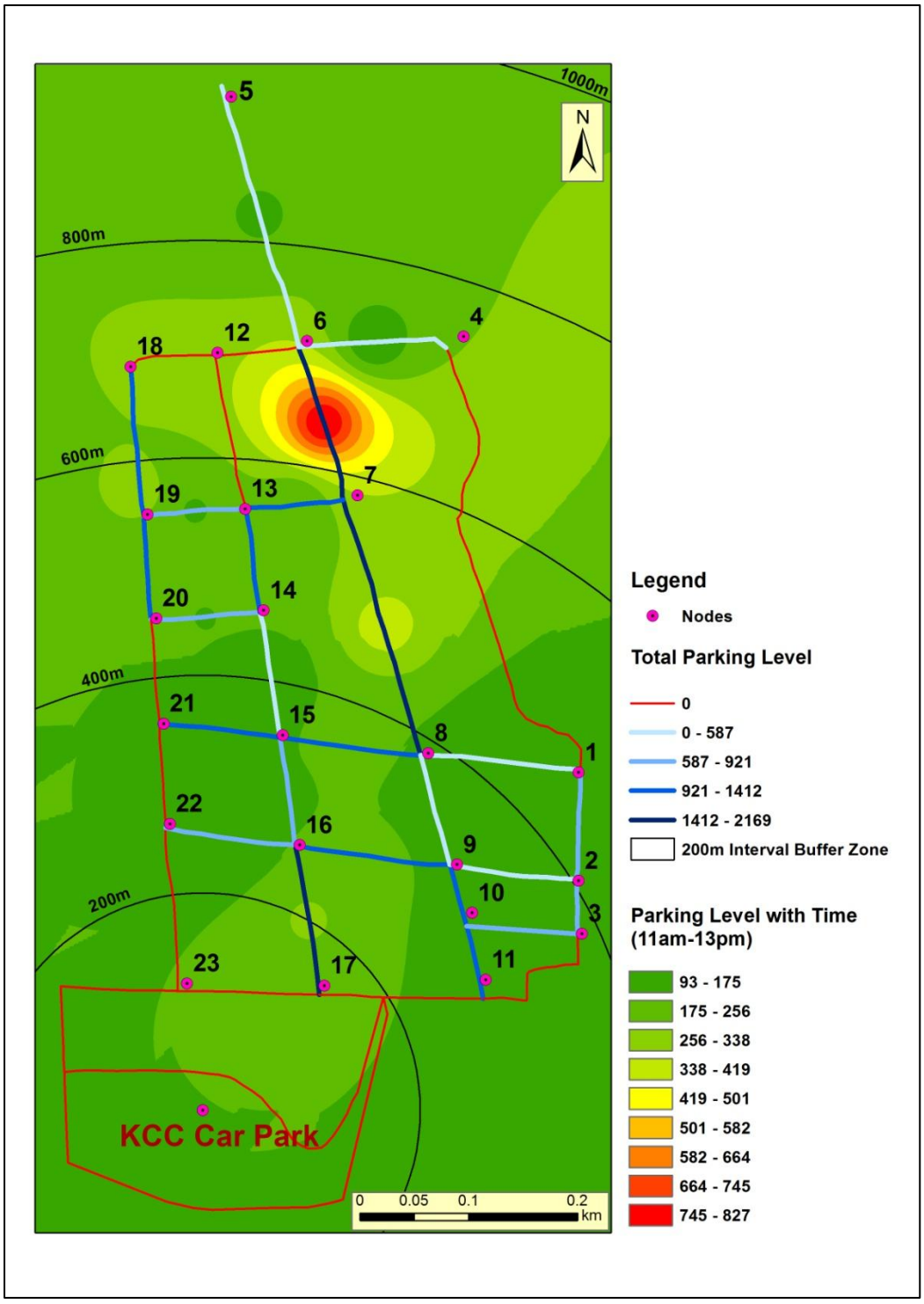

Figure 4.21: Graphical representation of On-street parking in 11:00-13:00

In this time interval parking demand for all segments except the segment 6-7 has less values of parking demand. Segments 6-7 have high attraction for parking, because this segment is close to two main schools in segment 12-6 and 5-6 (Figure 4.18) and these segments are prohibited for parking, due to that parking demand in 6-7 is in a higher value.

Table 4.19 - On street and Off street parking data 11:00-13:00

	Time	**On street**	**Off street**
Time Interval 11:00-13:00	11:00	1160 (825)	1054 (850)
	13:00	1230 (825)	1056 (850)

Demand for on street and off street parking has high values but it not shows high parking demand for on street segments except 6-7. Because sharing parking lots is in a high value in this time period. Again the highest demand showing segment in this time period, segment 6-7 has the highest distance from the off street car park. Also this is the time period both parking types reached a maximum value.

iv) Time interval 13:00 – 15:00

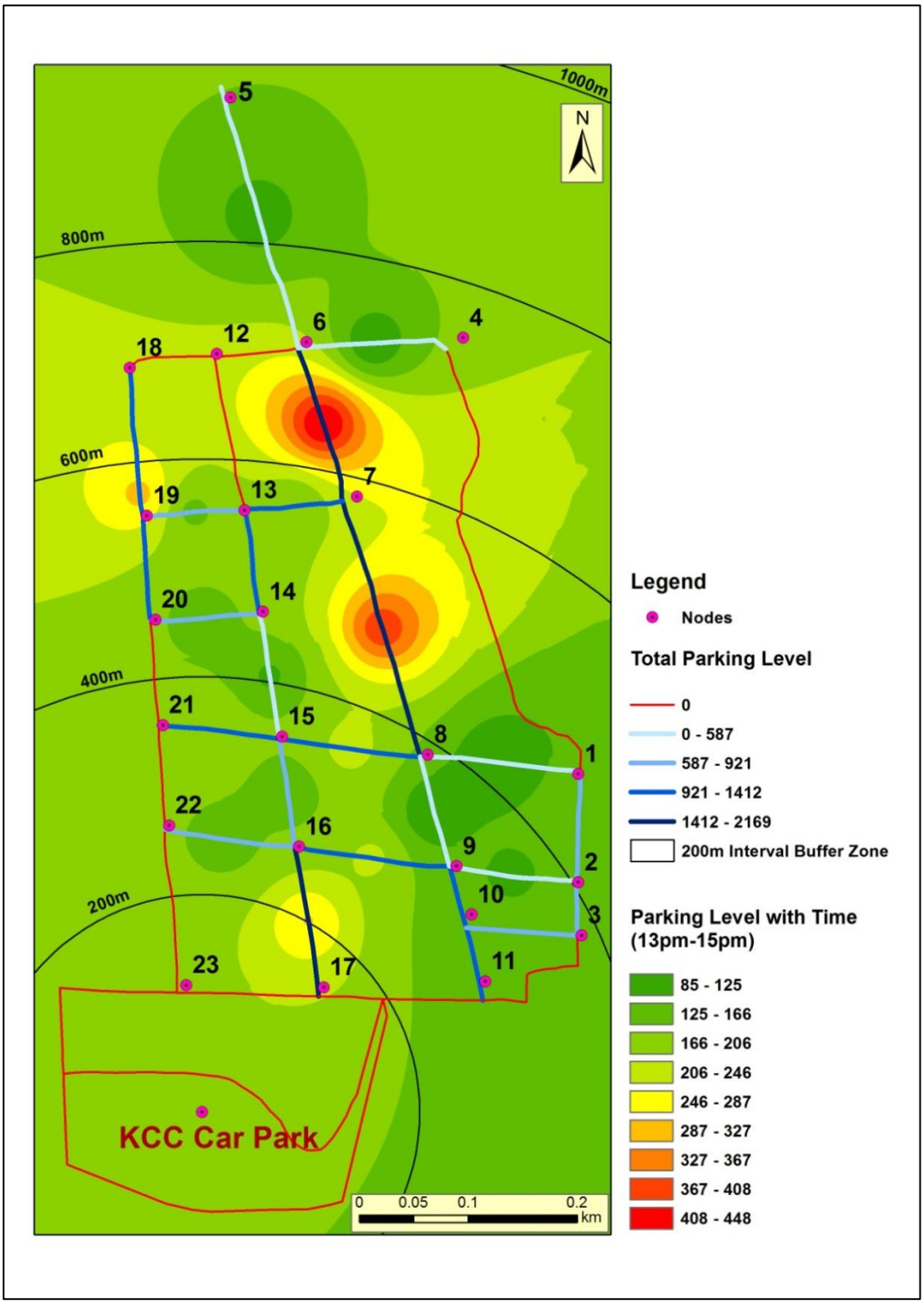

Figure 4.22 : Graphical representation of On-street parking in 13:00-15:00

In this time interval parking demand for 6-7, 7-8 and 18-19 has high attraction for parking. Most of the vehicles parking along these segments in this time period are due to the school hours. Those segments have the highest distance from the off-street car park and clearly can see people are attracting to park their vehicles close to their destination. Also parking attraction in 16-17 segments gradually start to increase.

Table 4.20 - On street and Off street data 13:00-15:00

	Time	**On street**	**Off street**
Time Interval 13:00-15:00	13:00	1145(825)	1013(850)
	15:00	1001(825)	923(850)

In this time period, parking demand of off street parking start to reduce.

v)Time interval 15:00 – 17:00

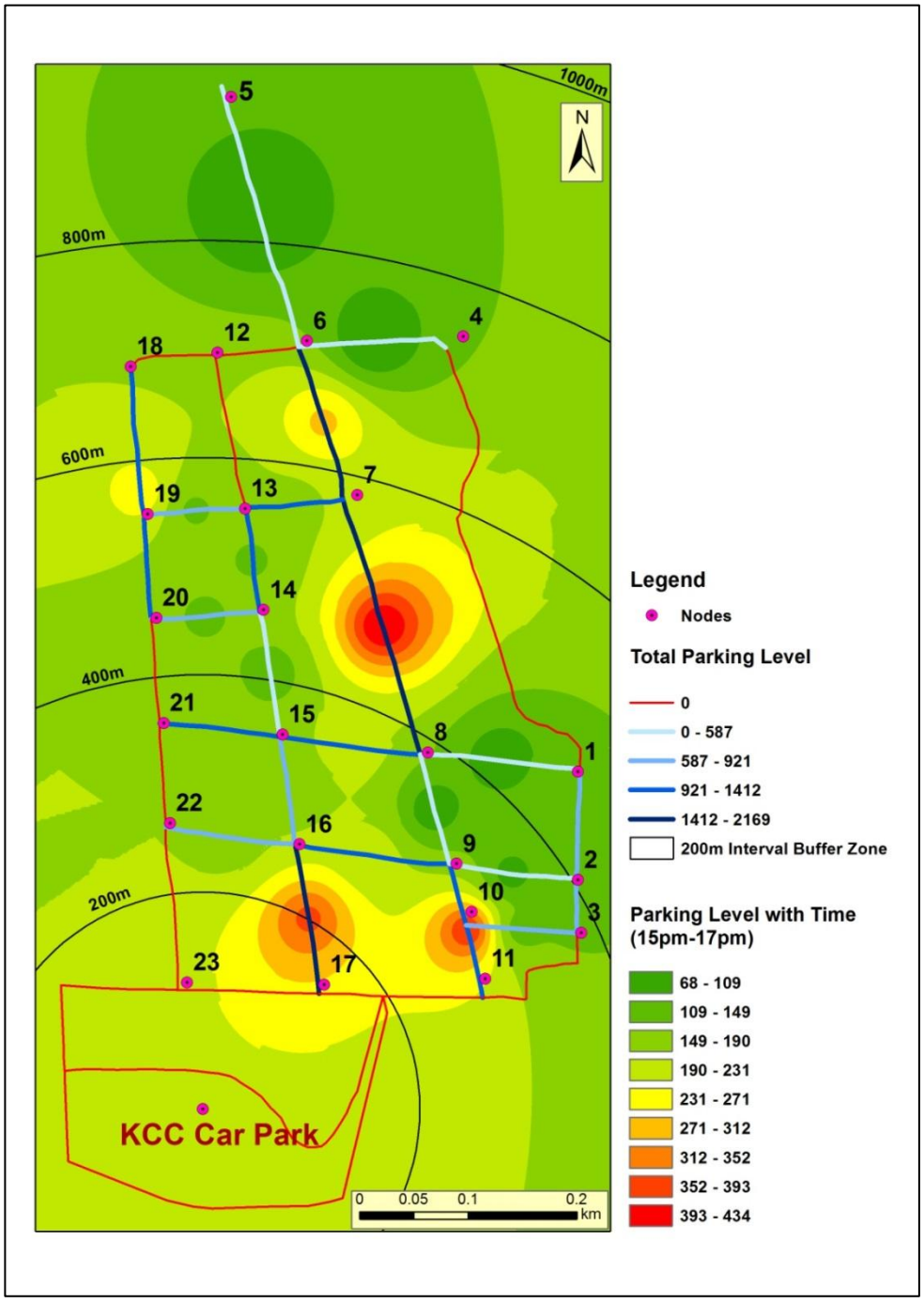

Figure 4.23: Graphical representation of On street parking in 15:00-17:00

According to the above it shows that segment 16-17, 9-11 and 7-8 has the highest demand for parking. Parking attraction for 6-7 and 18-19 segments getting reduce in this time period comparing to the other hours.

These segments are mainly located around garment product shops and especially 9-11 is very close to the Temple of Tooth Relic and in the evening time more pilgrims may visit the place by parking their vehicles close to their destination.

The 16-17 and 9-11 segments are very close to the off street park and at that time period demand of off street parking also getting reduces. But people are tends to park closer to their destination with the walking distance (200m – 300m) to their destination is also very lower value.

Again the 7-8, 6-7 has the largest distance from the off street park and people tend to park those areas to reduce the walking distance to their destination.

Table 4.21 - On street and Off street parking data 15:00-17:00

	Time	**On street**	**Off street**
Time Interval 15:00-17:00	15:00	982(825)	892(850)
	17:00	1021(825)	814(850)

Demand for on street parking is reducing with the time but people are tends to park their vehicles on street.

vi) Time interval 17:00 – 19:00

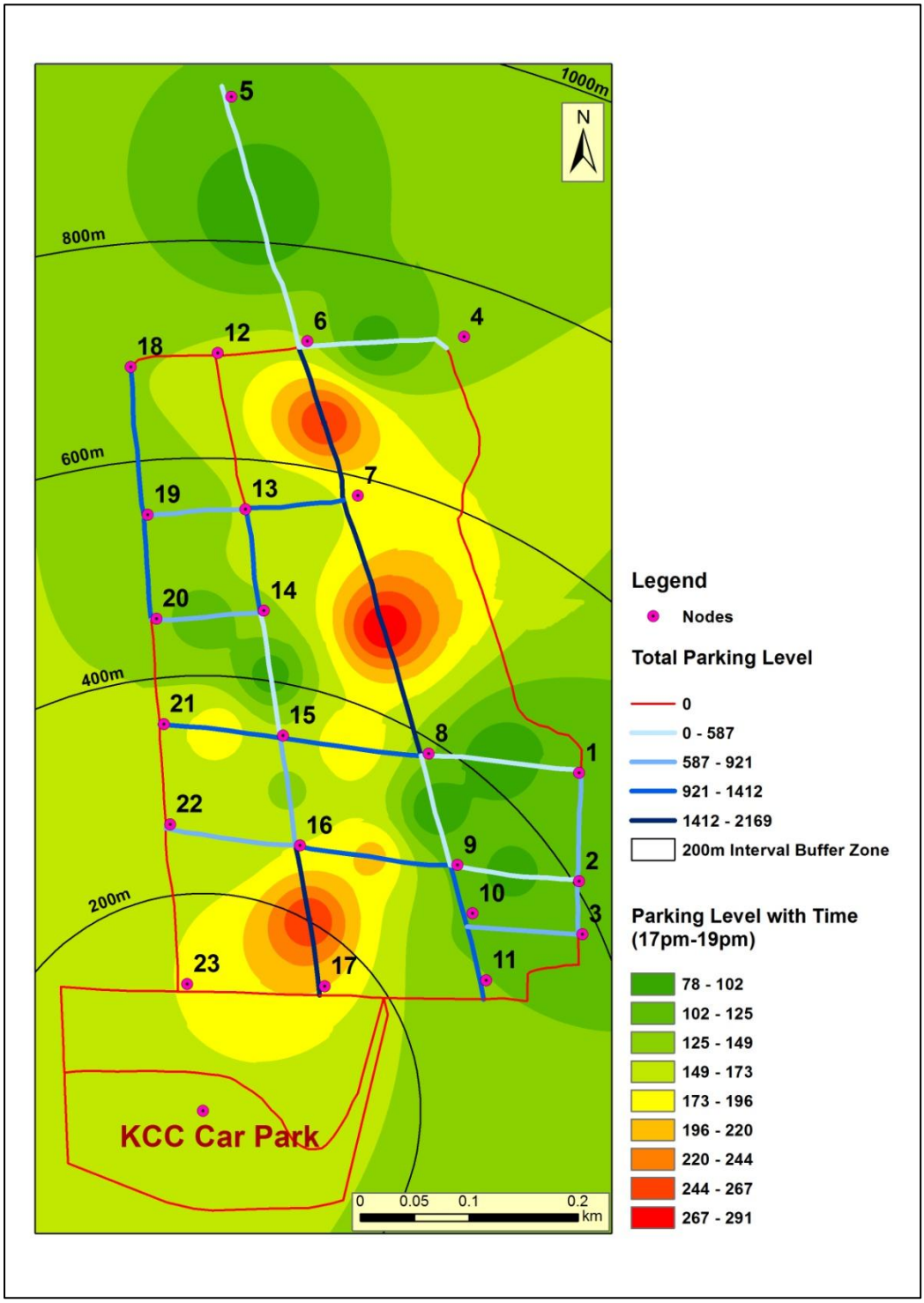

Figure 4.24 : Graphical representation of On street parking in 17:00-19:00

According to the figure 4.24 shows that segment 16-17, 6-7 and 7-8 has the highest attraction for parking. Main vehicle entry point for the study area from south direction with parking facilities is 16-17 segment. Therefore, people may tend to park on this segment in a situation with parking availability of the off street park is high.

From the north direction of the town first parking point is 6-7 and 7-8 and also people with the destination at the north of the town has to travel long distance to park their vehicles and have to walk large distance.

Table 4.22 - On street and Off street parking data 17:00-19:00

	Time	**On street**	**Off street**
Time Interval 17:00-19:00	17:00	1043 (825)	786 (850)
	19:00	710 (825)	462 (850)

Demand for on street and off street park getting reduces with the end of the most commercial activities.

4.2.2 Relationship with the peak hour traffic movement

Following Table 4.23 shows the peak hour of traffic movement in each node.

Table 4.23 - Traffic movement peak hours of each node 7:00-19:00

Node	Peak hour
6	7.30-8.30
7	8.30-9.30
8	16.45-17.45
9	16.45-17.45
13	11.00-12.00
16	11.00-12.00
17	7.30-8.30

18	16.30-17.30
19	16.30-17.30
21	16.30-17.30
22	13.00-14.00
23	11.15-12.15

Table 4.24 - Relationship of parking with the peak turning movements

Time Interval	**Segments with highest parking demand**
7.00-9.00	According to figure 4.16, segment 16-17 has the highest demand of parking. From South to the town area main entry points are 23 and 17. Out of the two nodes 16-17 segments has the parking facilities and 17 node has the peak hour of traffic at this time period.
9.00-11.00	According to the figure 4.17 segment 7-8 has the highest demand of parking and 7 node has the peak traffic movements happening from 8.30 – 9.30.
15.00-17.00	8-10 segments has high attraction for parking except the other times of the day and 8,9 nodes have high attraction for traffic moments happening in this time period.

4.3 Comparison of On-street and Off-street parking with the daily traffic movement in Kandy City

Data shown in Appendix 6 were used to find the total traffic flow in and out of the Kandy city within a day and Figure 4.25 shows the main traffic entry and exit points of the town area.

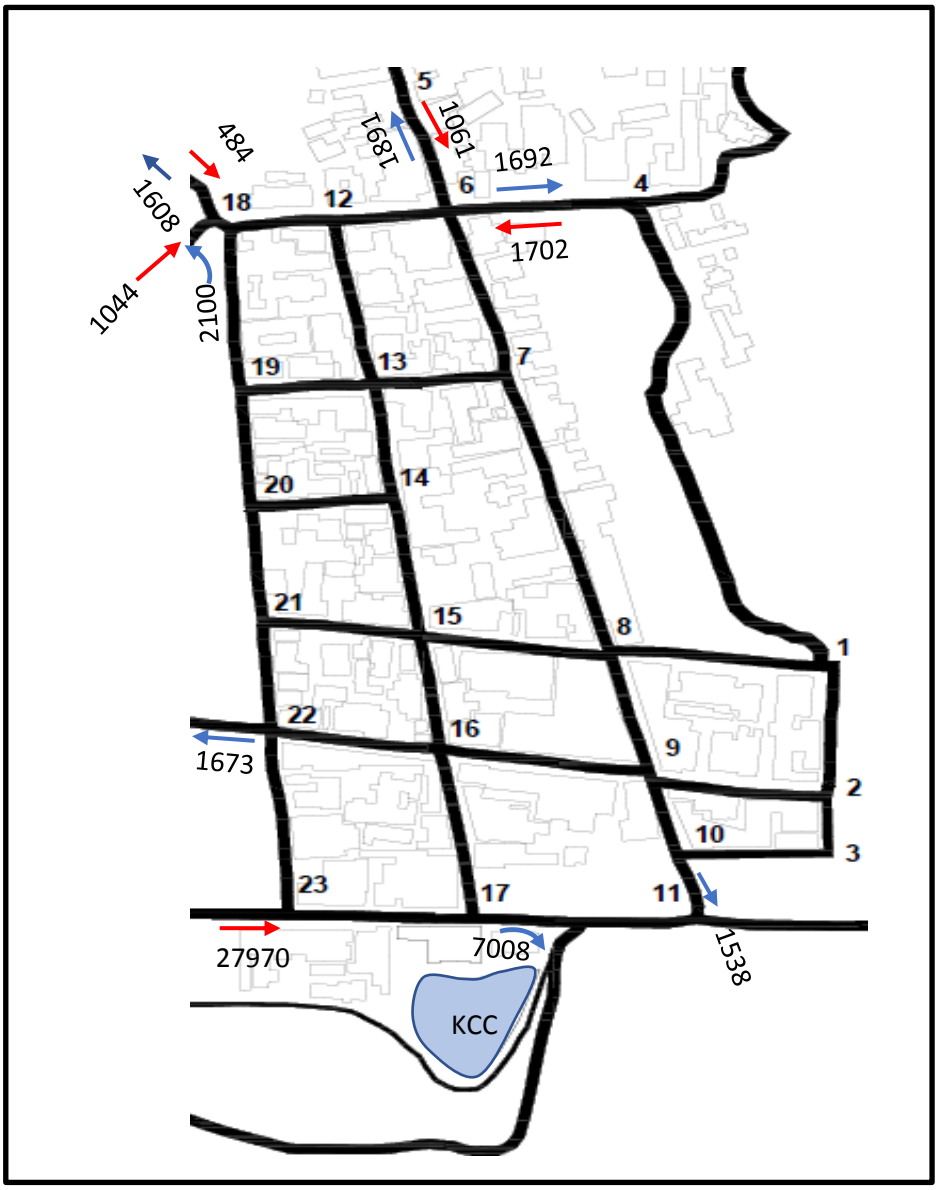

Figure 4.25:In and Out traffic volume to the Kandy city

Table 4.25 gives the total number of on street and off street parking in the Kandy city from 7.00 am to 19.00 pm.

Table 4.25 - On street and Off street parking data 7:00-19:00

Type of parking	**No of Parked vehicles**
Off street parking	18005
On street parking	24133

According to the above results it can conclude attraction for the parking in on street is higher than the attraction for parking in off street car park. From main entry points to the study area from south and north directions with on street parking facilities has the highest demand for parking.

5 LIMITATIONS

- Dedicated parking spaces such as private and government own parking spaces (government departments, institutions, state own enterprises, and schools) that won't affect the supply and the demand of parking in the area is not considered in this study even though there is an impact on the overall parking situation and the traffic congestion in the area.
- Parking levels were calculated according to the parking survey conducted for 30 minutes intervals. Therefore, the parking level is not in a same value within the 30 minutes time. On street parking is a share type of parking and within 30 minutes time interval. During that time period vehicles are leaving and entering to the parking spaces and parking level is changing. This difference is a very small value and that was neglected. The relationship between the parking levels with the vehicle speed can accurately observe using speed cameras.
- The angle of parking is not clearly defined for the on street parking and 60^{0} was used to calculate the parking level for angle parking. This cause to make small changes in parking level and this was neglected.

6 CONCLUSION

- Traffic speeds generally fell gradually with an increase in parking levels. Narrow width streets have the lesser and wider streets have the higher mean speed.
- The degree of correlation value of relationship between speed and parking level is not good for narrow streets ($R^2 = 0.2166$) and it gives clear picture of that on-street parking tends to slow down speeding vehicles. In narrow streets, beyond the parking level 170 the speed reduction level value turns to a steady value.
- Parking on streets directly affects the speed of the vehicle flow and it is related with the width of the streets. Therefore, it can conclude that on street parking has a large effect for the traffic flow.
- On street and off street peak parking demand occur at two different times. Both parking types have nearly similar pattern except some gradual increase and decreases of variations in on street parking.
- Spatial analysis results shows that motorists tend to park their vehicles on street in the morning hours. Also, results represents that users are attractive to park on street to reduce the walking distance to their destination without parking their vehicles in off street car park.
- Attraction for the parking in on street is higher than the attraction for parking in off street car park.
- From main entry points to the study area from south and north directions with on street parking facilities has the highest demand for parking.

7 RECOMMENDATIONS

- On street parking has a higher effect to the traffic flow and it is required to identify a sustainable solution for traffic congestion presents in today in many historical cities around the world.
- The results of speed analysis shows increasing in the on street parking cause to reduce the speed of the traffic flow and this is evident in both angle and parallel parking categories. This may be useful for policy makers to consider the role of on-street parking as part of their local area speed management strategies especially in historical cities like Kandy where streets are only designed for most traditional form of transport not for the large influx of traffic.
- The relevant departments shall study the parking supply and demand and develop a guide policy with a more reasonable pricing mechanism based on the parking demand.
- New policies shall encourage the community to open their unoccupied parking lots to public for relieving parking spaces shortage and generate revenue.
- The local government shall strictly monitor and regulate the commercial vehicle parking during the daytime since such loading and unloading will generate more traffic.

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