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On Street Parking Management Plan and Cost-Benefit Analysis for Dharwad City, Karnataka, India

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ABSTRACT
The propensity to own private vehicles and the necessity for their use has generated huge parking demand in metropolitan cities. Almost all the metropolitan cities are experiencing increasing problems related to parking. When all impacts are considered, improved management is often the best solution to parking problems. Parking management refers to various policies and programs that result in more efficient use of parking resources.
Problems with current parking practices are studied with the parking accumulation and supply survey in Dharwad. To find out the appropriate parking fee prior the new parking services go in operation, willingness to pay survey was conducted to know the willingness of the potential user's for the new services. Parking management strategies (short term, medium term and long term) and the way they can be implemented are discussed. The costs of proposed parking facilities, savings and improvements (change in LOS of the roads) that can result from improved management is calculated. Parking demand models are developed with the help of SPSS software. Models are generated using linear regression analysis for three different conditions with the data obtained from the willingness to pay survey. To solve the parking problems immediately, short-term solution are recommended with congestion pricing.

Keywords **-** Advance Parking Management Systems, Level of Service (LOS), Parking Management, Willingness to Pay(WTP).

1. INTRODUCTION
The increase in the heavy concentration of population in few metropolitan cities in the country has resulted in increase in the travel demand and is very continuous.

It is a well known that the limited availability of parking in the metropolitan cities contributes to roadway congestion, air pollution and driver frustration. As such, the cost of expanding traditional parking capacity is frequently prohibitive in most of the Indian metropolitan cities. While the available parking spaces are very limited, the vehicles intending to use these spaces are very large in number resulting in mis-match and avoidable wastage of fuel in locating for the parking spaces. Time is valued in terms of money in transport studies, because some drivers are willing to pay for travel time saving. Thus, parking policy measures not only affect the parking operational system but also generate impacts on the mobility and socioeconomic system of a city. Furthermore, parking policies can be thus designed and employed to influence mobility behavior in urban areas for instance, the accessibility of some zones can be greatly reduced by imposing high parking fees. The decision for the appropriate strategy should include analysis of the impacts on local economy.

However, the viability of a project dealing with implementing new parking services mainly depends on the method and the accuracy of estimation of the appropriate parking fee the potential users will be charged. An unreasonable high fee will decrease the demand and may jeopardize the payback of the project. Every day a significant percentage of drivers in single-occupancy vehicles search for a parking space. Additionally, less experienced drivers or out-of-towners further contribute to the increase of traffic congestion. Search for a vacant parking space is a typical example of a search process. Every parking search strategy is composed of a set of vague rules. It is usually difficult to describe these rules explicitly. The type of the planned activity, time of a day, day of the week, current congestion on particular routes, knowledge of city streets and potentially available parking places have significant influence on a chosen parking search strategy.

With a view to explore the possibilities of managing the parking spaces by appropriately communicating the information to the users, various options of ITS technologies have to be explored in the cities. When appropriately applied parking management can significantly reduce the number of parking spaces required in a particular situation, providing a variety of economic, social and environmental benefits. When all impacts are considered, improved management is often the best solution to parking problems.

The need for the study and its type is further discussed in the following paragraphs.

2 NEED FOR THE STUDY
With the phenomenal increase in personalized motor vehicles, one of the major problems confronted by the motorists is the acute shortage of parking space. In the absence of adequate organized parking space, the invaluable road space is being used for vehicular parking. Obviously, the demand for parking has increased in alarming proportion in Central Business District (CBD) areas and other work/activity centers of the cities. A significant fraction of the trip time in a congested urban area may be spent looking for parking space. Where car parking spaces are a scarce commodity and owners have not made suitable arrangements for their own parking, ad hoc

overspill parking often takes place along sections of road, residential streets, foot paths and green verges of the roads which causes frequent traffic jams. This problem is required to be solved proactively by managing on-street parking at prominent places.

3 OBJECTIVES

The objectives of the paper are:

a) To assess the parking characteristics including parking duration and accumulation.
b) To assess the willingness of the commuters' to pay the on-street parking fee based on willingness to pay survey.
c) To evaluate the parking fee and the revenue generated per day for on street.
d) To estimate the future quantum of vehicles parked based on the above compiled data and thereby estimation of the corresponding revenue generated.
e) To select, develop and operationalize a parking demand model using software package, appropriate to the conditions and planning needs of the study area.
f) To assess the relevance of existing strategy, identify the consequences of pursuing alternative parking strategies and recommend / update a parking strategy for the study area up to 2020 based on cost benefit analysis of the alternatives.

4 STUDY AREAS AND CONTEXT

The study was conducted in Dharwad of Karnataka state in India. It has present population of about 5 lakh and covers an area of 101sqkm. Dharwad is the district head quarters and is the educational, financial and industrial hub for North Karnataka. The city is provided with necessary communication and infrastructure facilities like rail, road, telecommunication, radio and television stations, internet etc. National Highway No. 4 connecting Bangalore to Pune is like a backbone. The density of roads in the town is approximately 3.29 km/sqkm. The average width of the roads in the town is 9.5m. Roads cover an area of 22.69sqkm, which constitutes 22% of the developed area. The annual vehicular growth is observed to be 5.56%. Henceforth, the parking arrangements for these vehicles are not less than a mammoth task for the authorities.

Parking studies was carried out for the selected number of parking areas where parking demand is high, greatly influencing the vehicular and pedestrian movement. Of the total number of vehicles parked in the lots considered, 89.1% were two wheelers, 0.3% were three wheelers and 10.6% were four wheelers in Dharwad. CBD areas are greatly affected by parking hence, areas under the influence of CBD activities are considered for the study.

The methodology adopted, to achieve the objectives of the above-mentioned study, is discussed in the following paragraphs.

5 METHODOLOGY AND PARKING SURVEYS

The following methodology was adopted in the study.

a) Review of Available Reports and Plans: Study of available reports, plans, survey data and statistics related to Dharwad were identified, compiled and reviewed. The parking codes and practices were studied. In addition, the relevant agencies and government departments were contacted for collection of secondary sources of information. Traffic volume count carried out during the previous study was analyzed to find the level of service of the roads present in the study areas. Secondary data collected was consolidated and the data gaps were assessed.

b) Selection of Parking Lots: The study was conducted in the 2011. It was restricted to CBD areas i.e, 750m radius with respect to city bus terminal where parking demand is expected to be high causing heavy congestion due to commercial activities. Around 20 parking lots were selected and are represented in Table 1.

Table 1 Parking Lot Description

Lot Description	Lot No
In front of Hoysala hotel	1A
In front of Dharwar hotel	1B
Jubilee circle to St.Joseph school	2
Corporation road	3
Corporation to CBT circle	4
In front of Vijaya theatre	5A
In front of police station	5B
Shivaji circle road	6
Shivaji circle road next to Regal theatre	7
Subash road opp bus stand	8
Infront of Shiva sagar hotel	9A
Subash road	9B
Vivekanada circle	10
Shiva sagar hotel to Kamat hotel	11
Kamath hotel to Manish sarees	12
Selection centre to Akki road	13
Selection to KCC bank	14A
Manish sarees to KCC bank	14B
CBT Circle to jubilee circle	15

c) Types of surveys conducted: Parking space (supply) survey, parking accumulation survey and willingness to pay survey were the parking surveys conducted. The demand for parking has increased in alarming proportion in Central Business District (CBD) areas and other work/activity centers of both the cities.

d) Conduct of surveys: The procedure adopted for various parking surveys is explained in the below paragraphs:

Parking space (supply) survey: Each survey recorded the length of available parking space, street width, traffic management measures in force, such as prohibited turns, one

way streets, etc, type of traffic signs for regulation of parking, vacant and unused land suitable for temporary or permanent parking space and the restrictions that operate along each length. Where individual spaces were not defined using road markings (i.e. in uncontrolled areas), the number of spaces provided is based upon the assumption that each space is 2.5m*5m for four wheelers and 1.0*2.5m for two wheelers.

Parking accumulation survey: Parking accumulation survey was conducted simultaneously with the willingness to pay survey so as to correlate the present parking information with the previous study. The study region was divided into various blocks and parking accumulation survey was carried out at all selected road sections and adjoining public and private parking areas within each block. Studies were carried out even at few existing off street parking lots in both the cities. The registration plate method was used to collect the data for all the categories of vehicles on the typical working day for the for ten hours from 10:00am to 8:00pm at every half an hour interval.

Willingness to pay survey: The population consisted of drivers who live or visit the CBT areas were selected randomly. The length of each interview was designed to last no longer than 10min. In total, 307 valid interviews were conducted by trained interviewers. The interviews were conducted during the peak hours which are 11:00–03:00 and 4:00–08:00. The owners or the drivers of the vehicles were interviewed at the time of parking and un parking their vehicle. The methodology was adopted to ensure random sampling depended on traffic congestion conditions in the areas where the new parking facilities would be located. As almost all the roads selected had LOS E and F based on the previous study data, the numbers of interviewers selected were 10% of the supply of the particular parking lot.

e) Analysis of data and inferences**:** Data obtained from all the parking surveys was analyzed in terms of computation of various parking characteristics, especially parking accumulation, parking duration, parking index, parking turn over ,need for off street (multi level) parking and opinion of the commuters acceptance of different parking management plans. Inferences were drawn based on the analysis of the data.

f) Suggestions and recommendations: The data analysis and the inferences drawn helped in providing certain suggestions and recommending certain measures to control the problem of parking in the area.

6 PARKING SURVEY AND WILLINGNESS TO PAY SURVEY ANALYSIS

6.1 Parking supply survey

Parking supply obtained from the parking space (supply) survey is given in Table 2.

6.2 Parking accumulation analysis

The parking accumulation data collected from parking accumulation and duration surveys carried out for on-street and off-street parking areas within the influence area were compiled and analyzed to work out the accumulation and duration of parking.

6.3 Parking duration analysis

Parking duration analysis was carried out to find the length of time spent in a parking space by the vehicle. From the analysis, it was observed that, short duration parking is high in both the cities i.e. the vehicles parked for half an hour are more compared to other duration. Because of which parking turn-over is high causing congestion on the streets. So as to reduce parking turn-over heavy parking fee is to be levied on the short duration parking vehicles.

6.4 Parking adequacy (index) analysis

This was done by matching the base year parking supply and accumulation of vehicles. Analysis was done to know whether the existing supply can cater the present parking demand. Supply and accumulation analysis results for the base year have been tabulated in Table 3. It was observed that, majority of parking lots has already crossed their capacity and some are about to cross the capacity.

Table 2 Parking Supply Description

Lot Description	**Lot No**	**Vehicle Type**	**Supply**
In front of Hoysala hotel	1A	2-w	125
In front of Dharwar hotel	1B	2-w	15
		4-w	20
Jubilee circle to St.Joseph school	2	2-w	155
Corporation road	3	2-w	58
Corporation to CBT circle	4	2-w	64
In front of Vijaya theatre	5A	2-w	86

In front of police station	5B	2-w	7
		3-w	15
		4-w	10
Shivaji circle road	6	2-w	62
		4-w	24
Shivaji circle road next to Regal theatre	7	2-w	192
Subash road opp bus stand	8	2-w	103
Infront of Shiva sagar hotel	9A	2-w	44
Subash road	9B	2-w	98
Vivekanada circle	10	4-w	21
Shiva sagar hotel to Kamat hotel	11	2-w	77
		4-w	25
Kamath hotel to Manish sarees	12	2-w	69
Selection centre to Akki road	13	3-w	5
		4-w	12
Selection to KCC bank	14A	4-w	32
Manish sarees to KCC bank	14B	2-w	73
CBT Circle to jubilee circle	15	2-w	108
		4-w	15

Table 3 Parking Supply versus Accumulation for the Base Year (2011)

Lot No	Vehicle type	Supply	Morning			Evening		
			Morning occupied	Surplus and Shortfall	Accumulation / Supply	Evening occupied	Surplus and Shortfall	Accumulation/ Supply
1A	2-w	125	120	-5	0.96	112	-13	0.9
1B	2-w	15	22	7	1.47	22	7	1.47
	4-w	20	4	-16	0.20	2	-18	0.10
2	2-w	155	60	-95	0.39	60	-95	0.39
3	2-w	58	76	18	1.31	80	22	1.38
4	2-w	64	98	34	1.53	83	19	1.3
5A	2-w	86	98	12	1.14	120	34	1.4
5B	2-w	15	7	-8	0.47	5	-10	0.33
	3-w	10	3	7	0.3	4	6	0.6
	4-w	7	9	2	1.29	10	3	1.43
6	2-w	62	82	20	1.32	79	17	1.27
	4-w	24	32	8	1.33	34	10	1.42
7	2-w	192	66	-126	0.34	65	-127	0.34
8	2-w	103	137	34	1.33	129	26	1.25
9A	2-w	44	46	2	1.05	47	3	1.07
9B	2-w	98	89	-9	0.91	84	-14	0.86
10	4-w	21	36	15	1.71	35	14	1.67
11	2-w	77	47	-30	0.61	46	-31	0.6

	4-w	25	23	-2	0.92	23	-2	0.92
12	2-w	69	62	-7	0.9	53	-16	0.77
13	3-w	5	4	1	0.8	4	1	0.2
	4-w	12	4	-8	0.33	4	-8	0.33
14 A	4-w	32	21	-11	0.66	22	-10	0.69
14 B	2-w	73	65	-8	0.89	41	-32	0.56
15	2-w	108	70	-38	0.65	67	-41	0.62
	4-w	15	20	5	1.33	19	4	1.27

6.5 Parking turn over analysis

Parking turnover at the parking lots was used in the calculation of revenue generation from the proposed schemes.

Table 4 represents the parking turn-over rate of the vehicles.

Table 4 Parking Turn-Over Rate

Lot No	Vehicle type	Supply	No. of different vehicles utilizing parking space in a period of 10 hrs	Parking turn-over (NOs)
1A	2-w	125	216	1.7
1B	2-w	15	79	5.3
	4-w	20	41	2.1
2	2-w	155	698	4.5
3	2-w	58	487	8.4
4	2-w	64	500	7.8
5A	2-w	86	625	7.3
5B	2-w	7	68	9.7
6	2-w	62	445	7.2
	4-w	24	175	7.3
7	2-w	192	581	3.0
8	2-w	103	467	4.5
9A	2-w	44	374	8.5
9B	2-w	98	467	4.8
10	4-w	21	232	11.0
11	2-w	77	372	4.8
	4-w	25	210	8.4
12	2-w	69	322	4.7
13	3-w	5	13	2.6
	4-w	12	29	2.4
14A	4-w	32	189	5.9
14B	2-w	73	251	3.4
15	2-w	108	501	4.6
	4-w	15	47	3.1

6.6 Willingness to pay(WTP) analysis

The responses to the survey were received and the results were compiled and tabulated in Table 5.

From Table 5 it was observed that, 46% of the people said that parking space won't be available always.

Table 5 Summary of WTP Survey

Characteristics	Question		Response
			Dharwad
1. Sample characteristics	Sample size		137
	Vehicles accumulated		1342
	Literacy level-Graduate & above (%)		37.5
	Average age(in years)		40
2. What is the purpose of visit?	Shop owner (%)		32.3
	Work (%)		31
	Shopping (%)		24
	Education (%)		3
	Mode transfer (%)		9.7
3. Perception of parkers	Availability of space	Yes (%)	54
		No (%)	46
	Ease of parking	Very easy (%)	30
		Easy (%)	32.4
		Ok (%)	22
		Not easy (%)	12
		Difficult (%)	3
	Parked in front of shop	Yes (%)	56.7
		No (%)	43.3
	Reason of parking vehicle away from work place	Space not available in front of work place (%)	37.7
		Located centrally due to multiple works (%)	62.3
4. Frequency of parking	Daily (%)		43.4
	Twice a week (%)		17.9
	Weekly (%)		13.8
	Occasionally (%)		24.8
5. Preference for parking	Time restricted parking policy (%)		1.8
	Time dependent pricing policy (%)		3.6
	Not willing to pay (%)		0
6. Time restricted parking policy	Is free parking time of 30min sufficient?	Yes (%)	67
		No (%)	33
	Suggested average free parking duration(min)		60
	Is penalty of Rs10/hr for car and Rs5/hr for 2-w acceptable?	Yes (%)	27
		No (%)	73
	Suggested average penalty (Rs)	For car(Rs)	4
		For 2-w(Rs)	2
7.	Are parking charges up to 90min of Rs 5 for car &	Yes (%)	50

Time dependent pricing policy	Rs 3 for 2-w acceptable?	No (%)	50
	Suggested fee if unaccepted	For car(Rs)	3
		For 2-w(Rs)	2
	Are parking duration up to 90min to 8hr of Rs 8 for car & Rs 5 for 2-w acceptable?	Yes (%)	55
		No (%)	45
	Suggested fee if unaccepted	For car(Rs)	5
		For 2-w(Rs)	2
	Are parking duration up to 1 day of Rs 10 for car & Rs 7 for 2w sufficient?	Yes (%)	65
		No (%)	35
	Suggested fee if unaccepted	For car(Rs)	7
		For 2-w(Rs)	4

6.7 Level of Service(LOS)

Level of service is found to describe the traffic conditions such as speed & travel time, freedom of man oeuvre, traffic interruption, comfort, convenience & safety. LOS on midblocks were determined using IRC-SP 41.Table 6 represent the existing LOS analyzed for the study area.

Table 6 Level of Service for the Existing Midblocks

Location	Peak Hr	Width (m)	Capacity (PCUs)	2011			2014			2016			2021		
				Veh	V/C	LOS	Veh	V/C	LOS	Veh	V/C	LOS	Veh	V/C	LOS
Tikare road	7:00-8:00	3.5	875	2134	>1	F	2508	>1	F	2796	>1	F	3649	>1	F
Shivsagar hotel to KCC bank	7:00-8:00	10	1739	1404	.8	C	1650	.9	D	1840	>1	F	2402	>1	F
Vivekanand lane	6:15-7:15	5.2	912	2290	>1	F	2691	>1	F	3000	>1	F	3916	>1	F
In front of old bus stand	7:00-8:00	18.9	3337	2052	.6	A	2411	.7	B	2688	.8	C	3509	>1	F
In front of police station	6:15-7:15	7.1	1923	1767	.9	D	2076	>1	F	2315	>1	F	3022	>1	F
CBT circle to jubilee circle	6:15-7:15	18.5	5099	2899	.6	A	3406	.7	B	3798	.8	C	4957	.9	D
CBT circle to corporation	7:00-8:00	7.2	2000	2407	>1	F	2828	>1	F	3153	>1	F	4115	>1	F
CBT circle to CBT	10.30 - 11.30	6	1650	2718	>1	F	3194	>1	F	3561	>1	F	4648	>1	F
Shivaji circle CBT	09.00 - 10:00	16	2743	1641	.6	A	1928	.7	B	2150	.8	C	2806	1	E

7 PARKING MANAGEMENT PROPOSALS AND DISCUSSION

Parking improvement schemes for Dharwad CBT and adjoining areas have been proposed considering all the relevant issues of parking. These include the existing traffic scenario in the

area considered, existing parking demand and supply, future parking potential, availability of open spaces, some parking schemes are proposed, etc. Accordingly, various options for improving the parking supply along the influence areas were evolved and critically evaluated. On-street parking is an extravagant use of the available carriageway. A judicious application of appropriate parking management measures should be combined with the proposals for on-street parking so as to mitigate some of its ill-effects. Keeping in view of the parking scenario and future demand, management solutions are proposed.

On-street parking management measures which were suggested are discussed in the following paragraphs.

7.1 Regulatory Measures for On-Street Parking as per IRC: SP: 43-1994

Prohibition of parking at certain locations is desirable to ensure safety and convenience. Parking is to be prohibited 50m on the approaches to a major intersection, narrow streets, pedestrian crossing, structures and entrance driveways. Suitable locations identified on the approaches to the major intersection where on- street parking is to be prohibited completely for a distance of about 50m are lots (1B and 4).In case of some parking lots (1A,4,6,7,8,14A,14B and 15) parking is to be banned partially.

7.2 On-Street Charging

If morning and evening parked vehicles for half an hour vary each other by more than 50% then different fee is assigned during morning and evening. Table 7 represents the parking fee assigned for the lots where the number of vehicles parked for half an hour in the morning and evening are nearly same.

Table 7 Proposed Parking Fee

Lot No	Parking fee for two wheelers					Parking fee for cars			
	<1 hr	1 to 2 hr	2 to 3 hr	3 to 4 hr	> 5 hr	<1 hr	1 to 2 hr	2 to 3 hr	>3 hr
2	2	4	6	8	10	-	-	-	-
3	8	10	12	15	17	-	-	-	-
4	8	10	12	15	17	-	-	-	-
5A	-	-	-	-	-	10	17	20	25
5B	10	12	15	17	20	-	-	-	-
6	-	-	-	-	-	10	15	17	20
7	8	10	12	15	17	-	-	-	-
9A	8	10	12	15	17	-	-	-	-
10	-	-	-	-	-	10	17	20	25
11	8	10	12	15	17	10	15	17	20
12	10	12	15	17	20	-	-	-	-
13	-	-	-	-	-	10	15	17	20
14B	10	12	15	17	20	-	-	-	-
15	10	12	15	17	20	10	15	17	20

Table 8 represents the parking fee assigned for the lots where the number of vehicles parked for half an hour in the morning and evening vary by 50% w.r.t each other.

Table 8 Proposed Parking Fee(Morning & Evening)

Time	Lot No	Parking fee for two wheelers					Parking fee for cars			
		<1 hr	1 to 2 hr	2 to 3 hr	3 to 4 hr	4 to 5 hr	<1 hr	1 to 2 hr	2 to 3 hr	>3 hr
Morning (10:00-3:00)	1A	6	8	10	12	14				
	8	10	12	15	17	20				
	14A						10	12	15	17
Evening (10:00-3:00)	1A	4	6	8	10	12				
	8	8	10	12	14	15				
	14A						15	18	20	22

The reason for collecting different parking fee is; it reduces parking congestion by which parking demand is distributed uniformly for the whole day i.e, minimum number of free spaces available at all the time of the day. Around 50% of the parkers were not willing to pay the desired parking fee as per WTP survey. Hence, there will be considerable reduction in the parking demand improving in the LOS of the parking lots. Table 9 represents the change in level of service of the parking lots after reduction in demand, projected to 2020.

Table 9 Improved Level of Service of the Parking Lots

Lot No	Veh type	Supply	2011		2014		2016		2021	
			Accumulation /supply	LOS	Accumulation /supply	LOS	Accumulation /supply	LOS	Accumulation /supply	LOS
1A	2-w	125	0.5	A	0.6	A	0.7	B	0.9	D
1B	2-w	15	0.8	C	0.9	D	1.0	E	>1	F
	4-w	20	0.1	A	0.1	A	0.1	A	0.2	A
2	2-w	155	0.2	A	0.2	A	0.3	A	0.4	A
3	2-w	58	0.8	C	0.9	D	1.0	E	>1	F
4	2-w	64	0.8	C	1.0	E	1.0	E	>1	F
5A	2-w	86	0.8	C	0.9	D	1.0	E	>1	F
5B	2-w	15	0.3	A	0.3	A	0.3	A	0.4	A
	3-w	10	0.2	A	0.3	A	0.3	A	0.4	A
	4-w	7	0.8	C	0.9	D	1.0	E	>1	F
6	2-w	62	0.7	B	0.9	D	1.0	E	>1	F
	4-w	24	0.8	C	0.9	D	1.0	E	>1	F
7	2-w	192	0.2	A	0.2	A	0.2	A	0.3	A
8	2-w	103	0.7	B	0.9	D	1.0	E	>1	F
9A	2-w	44	0.6	A	0.7	B	0.8	C	1.0	E
9B	2-w	98	0.5	A	0.6	A	0.7	B	0.9	D
10	4-w	21	0.9	D	1.0	E	>1	F	>1	F
11	2-w	77	0.3	A	0.4	A	0.4	A	0.6	A
	4-w	25	0.5	A	0.6	A	0.7	B	0.9	D
12	2-w	69	0.5	A	0.6	A	0.6	A	0.8	C
13	3-w	5	0.4	A	0.5	A	0.6	A	0.8	C
	4-w	12	0.2	A	0.2	A	0.2	A	0.3	A
14A	4-w	32	0.4	A	0.4	A	0.5	A	0.6	A
14B	2-w	73	0.5	A	0.6	A	0.6	A	0.8	C
15	2-w	108	0.4	A	0.4	A	0.5	A	0.6	A

7.3 Prohibition of parking during peak hours

It was observed that even though after collecting the parking fee till the design period some of the lots cross the accumulation to supply ratio of 0.8 which is an ideal ratio. To maintain the ideal ratio parking was to be prohibited during peak hours. But peak hour may vary as it's a random phenomenon hence prohibition time may vary accordingly. Table 10 represents the lots where parking prohibition was suggested with the prohibition time.

Table 10 Prohibition of Parking during Peak Hours

Lot No	Prohibited timing at peak hours
1A	1:00-6:00

3	5:00-8:00
4	12:00-2:00
5A	6:00-8:00
6	10:00-1:00
8	11:00-2:00
9A	5:30-7:30
9B	12:30-2:30

7.4 Shared use of available parking facilities
Sharing of parking spaces by two or more different firms greatly reduces requirement of extra parking spaces. The locations where shared parking can be adopted are, in front of Vijaya theatre and Corporation.
7.5 Identification of surface parking areas

Surface parking facilities were proposed as an option for the 1 site in Dharwad.
Table 11 represents the identified surface parking areas with the parking fee assigned.

Table 11 Identified Surface Parking Area

SI NO	Parameter		Dharwad
1	Location		Kalabhavan
2	Area(m^2)		6400m^2
3	Vehicles	2-w	461
		4-w	120
4	Parking Fee (<1 hr)	2-w	2
		4-w	5
5	Parking Fee (1 to 3hr)	2-w	3
		4-w	7

7.5.1 Parking fee assigned for on-street parking: Parking fee proposed for the vehicles parking on the street is tabulated in Table12.

Table 12 Fee Proposed for On-Street Parking

Sl. No.	Vehicle type	Duration of parking		
		On-street parking		
		< 1 hr	1 to 2 hr	>2 hr
1	Parking fee for Car	10	20	30
2	Parking fee for two wheeler	5	10	15

8. PARKING DEMAND MODEL DEVELOPMENT USING SPSS SOFTWARE

A realistic projection of parking demand is a prerequisite to plan for the future provision of parking infrastructure.
Parking demand models were developed with the help of SPSS software. Linear regression analysis was carried out. The parking demand models were formulated for rate of visit and purpose of visit factor, which greatly influence parking demand. These were obtained from the willingness to pay survey analysis.
Model obtained from the data of rate of visit factor is:
$D=0.337+7.093a+8.594b+9.16c+5.915d$ with $R^2=0.959$
The variables used in the above models are,
D=Demand for parking space in ECS.
a=Daily visit of the commuters.
b=Twice a week visit.
c=Weekly visit.
d=Occasionally visit.

Model obtained from the data of purpose of visit factor is:
$D=0.661+9.012a+8.516b+4.7c+6.091d+4.563e$ with $R^2=0.967$

The variables used in the above models are,
D=Demand for parking space in ECS.
a=Shop owner
b=Work.
c=Shopping.
d=Others.
e=Education.

9. FINANCIAL ANALYSIS

9.1 Financial Appraisal for the Above Proposals
The cost outflow consisting of both capital and recurring costs has been worked out for a project period of 15 years. The capital cost has been considered in the construction period of one year.

The recurring cost has been calculated over the entire project period by projecting the base year recurring cost inflated by four per cent to account for price escalation. Cost estimation was carried out for the proposed parking management proposals as in Table 13.

Table 13 Cost Estimate of Parking Development Schemes

Detailed cost estimate for parking development schemes for the base year			
Sl.No	**Type of scheme**	**Type of parking development scheme**	
		On-street parking	**Off-street surface parking**
	Capacity of system(No's)		
1	Car	193	120
2	Two wheeler	1203	461
	Cost of System		
	Capital Cost (Rs in millions)		
1	Construction cost	-	5.76
2	Miscellaneous expenditures	0.07	0.03
	Sub-total	0.07	5.79
	Recurring cost in the base year (Rs in millions)		
1	Operating cost	3.8	0.79
2	Maintenance cost	0.0013	0.12
	Sub-total	3.8	0.91
	Total cost in the base year (Rs in millions)	3.87	6.7

9.2 Revenue Generation

The proposed parking development schemes were expected to generate revenue throughout the project period. The revenue stream has been projected for the project period by increasing the parking fee by twenty per cent every five years to account for the inflation. In the case of parking development schemes, the major source of revenue is parking fee. Table 14 represents the annual revenue generated.

Table 14 Annual Revenue Generations for Different Schemes

Details of annual revenue generations from parking development schemes			
Sl.No	**Type of scheme**	**On-street parking**	**Off-street surface parking**
	Turnover of vehicles per day		
1	Car	764	475
2	Two wheeler	5,168.85	1,981
	Revenue stream in the base year (Rs million)		
	Total revenue	20.49	2.96

9.3 Internal Rate of Return (IRR)

IRR was obtained for each of parking development options for different project periods up to 15 years. The summary of FIRR arrived for various options of parking development schemes is represented in Table 15.

Table 15 Summary of IRR

Summary of IRR for various options of parking development schemes		
Project period (in years)	**On street parking**	**Off-street surface parking**
5	High	16%
10	High	29%
15	High	31%

10 CONCLUSIONS

With the phenomenal increase in personalized motor vehicles, one of the major problems confronted by the motorists is the acute shortage of parking space. The demand for parking has increased in alarming proportion in Central Business District (CBD) areas and other work/activity centers of the cities. The provision of multi-level parking and their effective use emerges as the most viable initiative in the cities. On the basis of the present study conducted in Dharwad the following conclusions have been drawn:

1. Based on the analysis of the accumulation pattern it was found that the maximum accumulation in the morning occurs between 12 noon to 2 PM and between 5 PM to 8 PM in the evening.
2. The study of parking duration analysis suggests that short duration parking is high. Hence, parking turn-over is high causing congestion on the streets. To reduce this, heavy parking fee is to be levied on the short duration parking vehicles.
3. Parking adequacy analysis suggests that majority of parking lots has already crossed their capacity and some are about to cross the capacity.
4. Very few streets have desired LOS and till 2020 almost all the streets gets jammed. Even though after prohibiting on-street parking in CBD, a desired LOS could not be achieved. Hence, congestion charging is suggested in such areas.
5. Prohibition of parking in peak hours is to be varied based on the variation in the peak accumulation in their respective parking lots.
6. To solve the parking problems immediately on-street parking management measures can be adopted with congestion pricing as, operation and maintenance cost is very much less for on-street parking management rather than off-street and even IRR is high in on-street parking.
7. Parking fee was assigned for on-street and off-street parking and financial evaluation was carried out. The fee for parking on the streets has been kept deliberately high compared to off-street parking so as to discourage the parkers to park on street.
8. The models developed from SPSS analysis can be used to find future parking demand.
9. The high demand for parking spaces in the horizon years could be effectively met by the development of automated parking system.

10.1 Recommendations

Based on the analysis and conclusions some of the recommendations are recommended which are mentioned below:

1. A Hubli Dharwad Metropolitan Parking Authority should be constituted at the earliest.
2. A Parking Audit should be conducted of existing buildings and land uses by a team especially constituted for the same, to determine the actual parking demand for the type of building / land use. The DC Rules need to be amended accordingly.
3. Any new development should be mandated to submit an Impact Statement, clearly setting out the impact it will have on all urban infrastructure, especially the transport infrastructure.
4. The parking charges should be revised to reflect to some extent the real estate values of the locality.
5. No on-street parking should be permitted, especially on arterial roads.
6. Parking restrictions are to be enforced forcefully, and traffic police will need to be empowered to do so.
7. Parking contours should be drawn with the CBD at the center, and the parking charges should be progressively increased towards the CBD.
8. Provide convenient and accurate information on parking availability and price, using maps, signs, brochures and electronic communication. Efficiency - Equity - Clarity" are the three things taken into consideration.
9. Shared parking should be entertained.

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