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Effecting Carrying Capacity of Parks in Korba City: Using Cifuentes Method

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Article History	Abstract
	In the process of rapid urbanization, the need for green open spaces is increasing, predominantly that of parks. Parks play a vital role in the social, economic, and physical well-being of city dwellers. Park visitors often prefer to visit parks, which have good potential to accommodate the optimal number of visitors without compromising the quality of experience. Due to the lack of understanding of parks and visitors' requirements, parks are either under-utilised or over-utilized. The optimal visitors carrying capacity is an important parameter to assess the optimal number of visitors an Urban park can accommodate in a given time. This study presents a method to calculate the optimal carrying capacity of visitors. For this purpose, a conventional three-level procedure of visitor carrying capacity for parks was considered in Korba City. In this regard, the physical, real and effective carrying capacity was estimated using "the Cifuentes method". For this study, three parks from Korba City (C.G., India) were selected that are Silver jubilee park, Smriti nagar park and Vivekanand Udyan. The finding of research indicates that the mentioned three parks were working below the limit of carrying capacity, which means the facilities are underutilised. The outcome signifies may serve as a tool for the future planning of parks as well as other type of ecological environment such as national parks and zoo used for recreational activities. Hence, landscape architects, city planners and policymakers can work in the direction to derive significant information about the parks and park visitors for the optimal utilisation of the park.
	Keywords: *Carrying Capacity, Urban Parks, Cifuentes method*

1. Introduction

Liu [1], in 2018, opined that for the development of urban areas, parks play a significant role. An Urban Park is a type of urban green space or open space area which are generally reserved for public use [2]–[4]. Urban And Regional Development Plans Formulation and Implementation Guidelines (URDPFI 2020) define urban parks as a type of public open spaces. As per The International Federation of Parks and Recreation Administration (IFPRA), the parks in urban areas are identified by the local authority of the region [2].

Globally, park managers are concerned about visitor-induced impacts and resource degradation [5]. However, Jogdande & Bandyopadhyay, 2022 [6] found that park managers and planners frequently lack an adequate understanding of visitors' experiences and usages of the park. Therefore, it is essential to know the perception of visitors on different factors associated with urban parks, as the performance of each factor decides the contribution of it to the engagement of visitors in urban parks. The concepts of evaluating park usage must be modified concerning the background of the study area and should be carried out by using multiple methods [6]. For the latter, park managers and policymakers of the park must set a tool to calculate carrying capacity, determine whether the park's conditions are in compliance with those of visitor's requirements, and take appropriate action when needed. All of these bring up the issue of how many visitors can ultimately be accommodated in the relevant area, which is frequently framed in terms of carrying capacity [3].

The term "carrying capacity" has a long history and originated in the shipping industry (the amount of freight a ship could carry). This term was later applied to other domains of study (like wildlife management and global population sustainability) [7]. Later on, researchers take into consideration the same in the recreational sector [7]– [12]. This paper intends to find out the factors which are associated with urban parks and assess the Visitor carrying capacity of the urban parks.

Literature study

The concept of carrying capacity (CC) was adapted to parks and outdoor recreation in mid -1930s due to the growing awareness of the limits of environmental resources and concern [7], [13]. The previous studies on CC of parks aim to explain the limits of acceptable change and find out its optimal uses [12]. The initial studies of CC for parks focused on the negative impact of visitors.

Whittaker 2011 [7] found that the park managers emphasized optimal carrying capacity and suggested limiting the recreational use of the park accordingly. This was expanded to include a new dimension of CC to reflect social values or experiences of visitors on park qualities [14]. Previous studies found that the experience and impact of visitor use are also associated with the number of visitors, which can be highly affected by managerial capacity and several other factors associated with urban parks [7]. CC of urban parks can be expressed in the number of visitors, with components of units of use, timing and location. CC is also known as recreation capacity, user capacity and visitor capacity [7], [10], [15], [16]. As per a previous study, "the maximum amounts and types of visitor use that an area can accommodate while achieving and maintaining desired resource conditions and visitor experiences that are consistent with the purposes for which the area was established" [17].

Visitor's Carrying capacity depends on several factors of parks, which encourage visitors to visit the parks [18]– [20]. It may be noted that very few studies have been conducted to determine the factors responsible for visiting any park and the optimal capacity of the park to accommodate visitors.

2. Materials And Methods

The selected factors of urban parks were derived from a regressive literature study in which authors had broadly focused on physical features, management and safety & security of urban parks. A total of twenty-four factors were selected based on the frequency of occurrence of each factor in the literature study. Playground, Lawn, Sitting / Public furniture, Waste disposal facilities, Paved pathway, Toilet/Restrooms, Food vendors, Parking, Waterbody, Playground equipment, Lighting, Entrance, Community Centre, Trees and Accessibility were the factors of physical feature which represents the quality of any urban park [11], [12], [21]–[35]. Factors of safety and security include safety and security and CCTV surveillance, whereas factors of management include Rules /regulations, Management unit/administration, Cleanliness and Fees [28], [32], [36]–[39] as mentioned in Figure 1.

Study Area Profile

Korba City has 13 parks as per Korba Master Plan 2031 (which include Silver jubilee park, Nehru Park, Ashok Vatika, Nehru nagar ground (park), Tagore Udyan, Pushpalata Udyan, Jai Meera Garden, Sarvamangla Park, Appu Garden (Vivekanand Udyan), Smriti nagar park, Children Park, Children Park (Jamnipali), Kathal Udyan, Bishahudas Mahant smriti, jubilee park, Bikash nagar park and CSEB park). However, for the study, three parks are selected based on three criteria using the purposive sampling method; 1) Designed for the people irrespective of any particular age group, 2) A minimum area of 1 hectare, 3) Frequently visited and has similar recreational facilities. Korba City has three recognizable public urban parks, which follow all the three criteria required for the study; Vivekanand Udyan (Appu Garden), Silver Jubilee Park, and Smriti Nagar Park. However, the size of these public urban parks are not the same. In terms of area, they are all very diverse from one another. According to Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines, Parks are categorized into five types, i.e., Housing area park, Neighbourhood Park, community park, district park, and sub-city park ranging from an area of 0.5 ha to 100 ha. In the present context, out of the three mentioned parks, Vivekananda Udyan and Smriti Nagar Park are recognized as neighbourhood parks, and Silver Jubilee Park has been recognized as a community park.

Methods for Carrying Capacity Assessment

The three-level calculation procedures of Cifuentes's (1992) method have been done to measure the optimal visitors carrying capacity of the parks of Korba City. The logic of the method is based on the site-specific factors that affect the quality and quantity of visitation and are considered the area's limitations. To assess the carrying capacity of public urban green parks.

Step I -Calculating Physical carrying capacity (PCC)

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According to the Cifuentes methodology, PCC is defined "as the number of visitors that can physically fit into the defined space, over a particular time. PCC is A/Au ×Rf. Where A is the Available area of green space, The size of each of the three parks has been measured during a field survey and with the help of Google Earth software. Au is Area required per person. The requirement of per capita space is determined as per URDPFI guidelines, that is, nine sq.m/ person. Rf is the Rotation factor (number of permissible visits per day) formulated as Rf= opening period / average time of one visit. The time period of each park slightly varies from each other's that have been collected.

S.NO.	FACTORS	FACTOR NO.
1	Playground	F1
2	Lawn	F2
3	Sitting/ Public furniture	F3
4	Waste disposal facilities	F4
5	Paved pathway	F5
6	Toilet/ Restrooms	F6
7	Food vendors	F7
8	Parking	F8
9	Waterbody	F9
10	Playground equipment	F10
11	Lightning	F11
12	Entrance	F12
13	Community centre	F13
14	Trees	F14
15	Accessibility	F15
16	Signage	F16
17	Water dinking facilities	F17
18	Aesthetic	F18

S.NO.	FACTORS	FACTOR NO.
19	Safety/ security	F19
20	CCTV surveillance	F20

S.NO.	FACTORS	FACTOR NO.
21	Rules & Regulations/ Policy	F21
22	Management unit/ Administration	F22
23	Cleanliness	F23
24	Fees	F24

FACTORS

2. safety & Security (Cf_2)

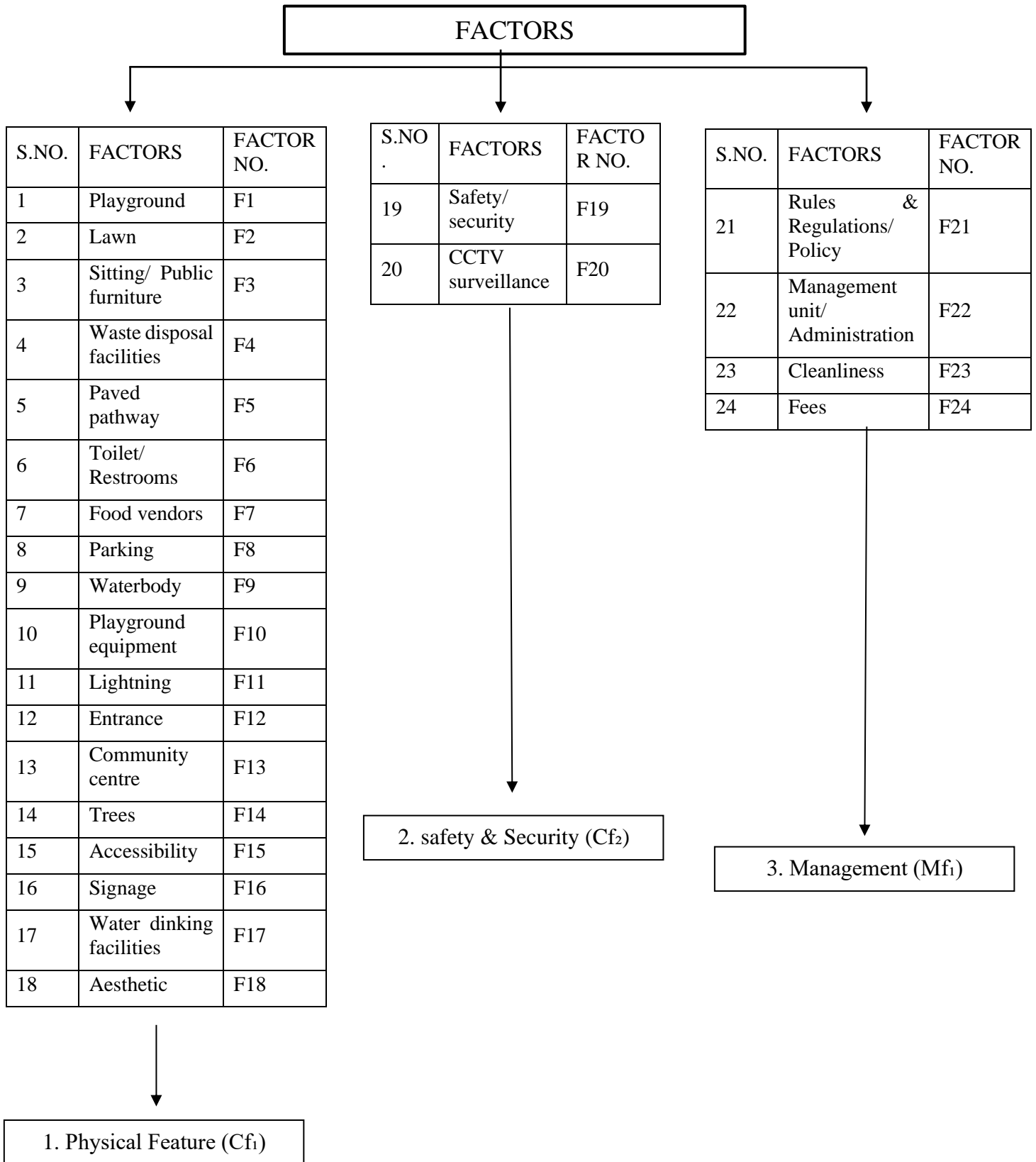3. Management (Mf_1)

1. Physical Feature (Cf_1)

Figure 1 Selected 24 potential factors responsible for the visitation
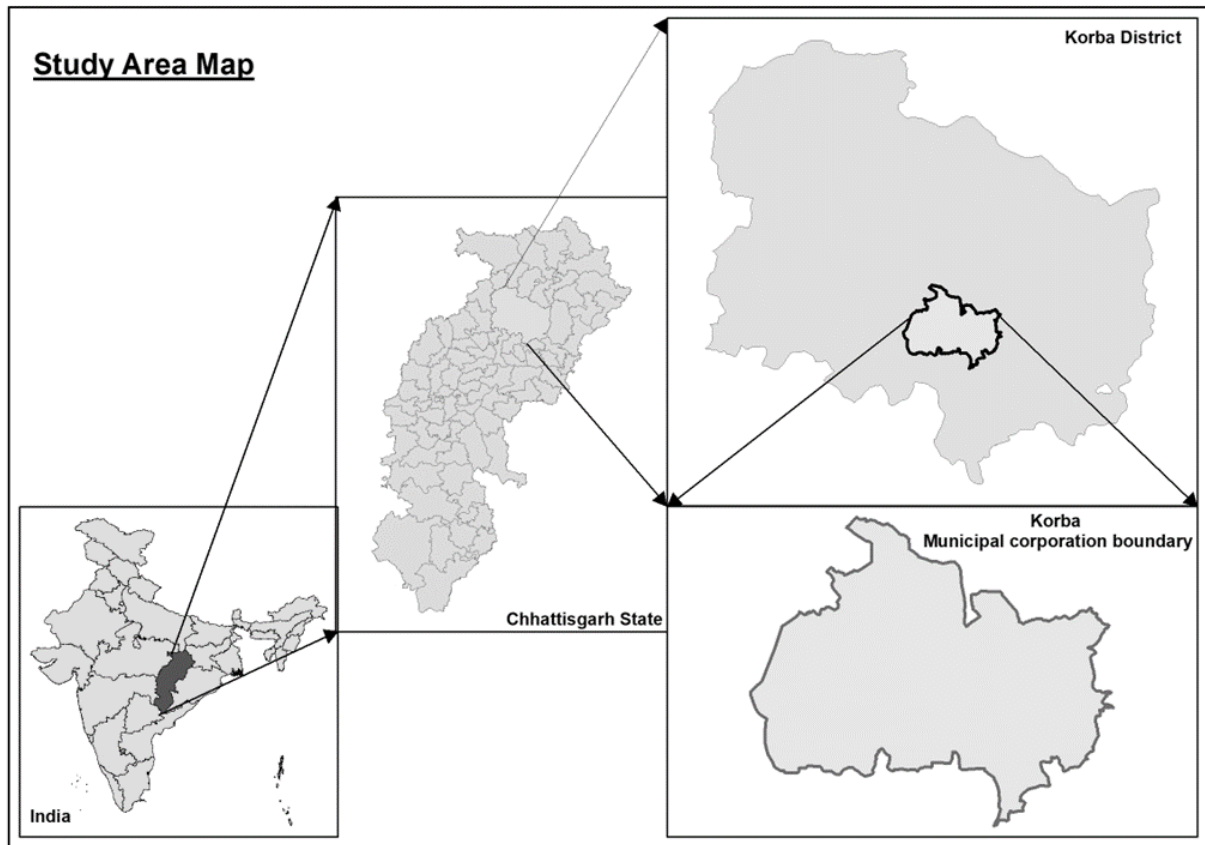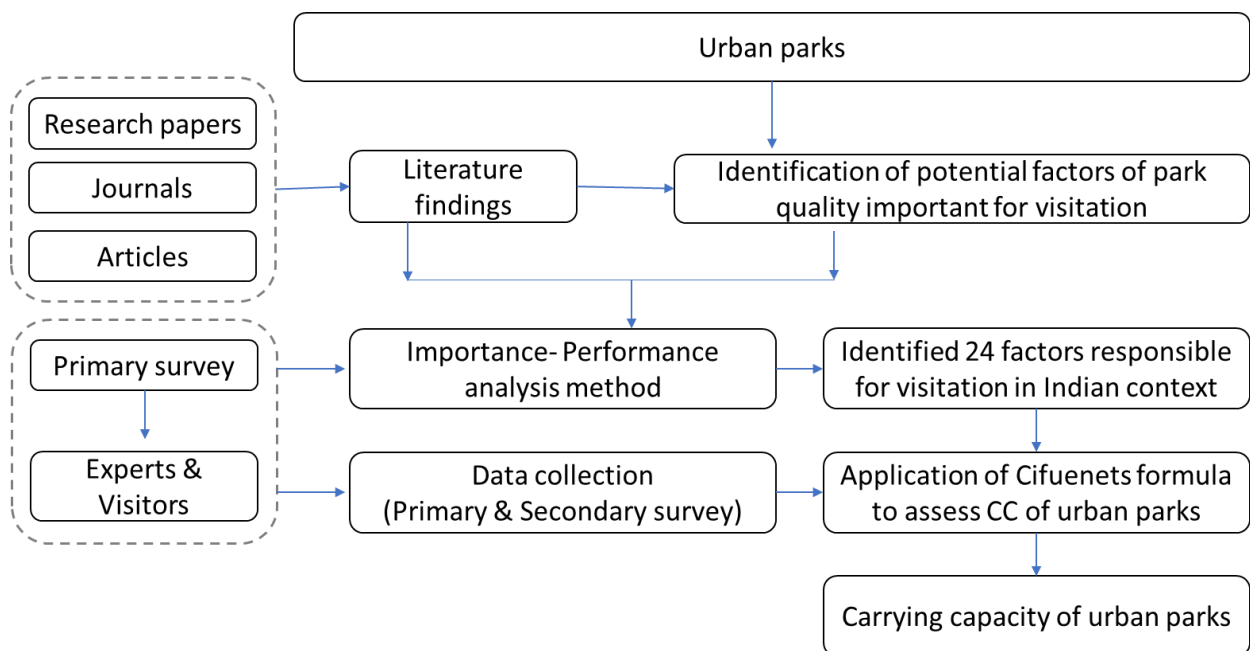
Figure 2 Location map of the study area

Figure 3. Flow Diagram representing the overall workflow adopted to arrive at the carrying capacity of public urban parks

From the park's survey, as Vivekanand Udyan is open for a duration of 8 hours per day, both Smriti nagar park and Silver Jubilee Park opening duration is 6 hours a day. The average time of visit is measured from the survey. The average visitation time of the Vivekanad Udyan, Smriti Nagar Park and Silver Jubilee Park are 1.1 hours,1.3 hours and 1.4 hours, respectively.

A person could theoretically visit more than one time during the opening hours of the visitation period a day. Since the average visit duration of Vivekanand Udyan is 1.1 hours. So, the rotation factor is calculated as Rf =8 / 1.1 = 7.3 visits. The average visit duration of Smriti Nagar Park is 1.3 hours. So, the rotation factor is calculated as Rf =6 / 1.3 = 4.6 visits. The average visit duration of Silver jubilee park is 1.4 hours. So, the rotation factor is calculated as Rf =6 / 1.4= 4.3 visits.

$PCC = (A/Au) \times Rf$ (1)

Where,

A= Available area of green space

Au=Area required per person

Rf= Rotation factor

Rf= Daily open period/ average time of visit per day

PCC for Smriti Nagar Park

$= (16121/9) \times 4.6 = 8267$ visitors/day

PCC for Vivekanad Udyan

$= (19401/9 \times 7.3 = 15678$ visitors/day

PCC for Silver Jubilee Park

$= (149575/9) \times 4.3 = 50713$ visitors /day

Table 1 Calculation of correction factor (Cf1)

S.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Factor No. / Park	F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10	F 11	F 12	F 13	F 14	F 15	F 16	F 17	F 18	Cf_1
1. Smiriti Nagar park	-	+	+	+	+	+	-	+	-	+	+	+	-	+	+	-	+	+	0.72
2. Vivekanand Udyan	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	0.83
3. SJP	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	0.89

Table 2 Calculation of correction factor (Cf2) and Management factor (Mf1) Using IPA method

S.No	19	20		21	22	23	24	
Factor No. / Park	F 19	F 20	Cf_2	F 21	F 22	F 23	F 24	Mf_1
1. Smiriti Nagar park	+	+	1	+	+	+	-	0.8
2. Vivekanand Udyan	+	+	1	+	+	+	-	0.8
3. SJP	+	+	1	+	+	+	-	0.8

Note:(-) factor need improvement & (+) factor need no improvement

Step II - Calculating Real carrying capacity. RCC is the maximum number of receivable visitors for the specific site once the correction (i.e., reductive) factors (Cf) derived from the particular characteristics of the site have been applied to the PCC. RCC= PCC× (Cf$_1$× Cf$_2$×…Cf$_n$). In the present context, two correction factors (physical feature Cf$_1$, safety & security Cf$_2$) have been assessed by setting some parameters. Cf is measured by the flowing formula-

$Cf_x = 1 - Lm_x/Tm_x$

Where Lm_x is the limiting magnitude of the variable, and Tm_x is the total magnitude of the variable, as shown in Table 1 and Table 2. Correction Factors (Cf) are closely linked to the specific conditions and characteristics of each site. Correction Factors (Cf) have been obtained from the Importance-Performance Analysis Method (IPA Method) based on the compiled opinion of visitors and experts on each factor. The questionnaire was framed for the visitors to rate each of the factors and asked to rate the factors in terms of performance on a 5-point Likert scale (1 = Very Poor, 2 = Below Average, 3 = Average, 4 = Above Average, 5 = Excellent). Simultaneously questionnaire asks the opinion of experts, to rate the factor in terms of its importance in parks on a 5-point Likert scale (1 = Not important at all, 2 = for little important, of average important, 4 = for very important, 5 = absolutely important). The compilation of ratings of both visitors and experts results in classifying the factors which need to be improved in Table 1 & Table 2

$RCC = PCC \times (Cf_1 \times Cf_2)$ (2)

Where,

PCC= Physical Carrying Capacity from equation (1)

Cf_1=Correction factor 1 (Physical feature)

Cf_2=Correction factor 2 (Safety and security)

RCC for Smriti Nagar Park

$= 8267 \times (0.72 \times 1) = 952$ visitors/day

RCC for Vivekanad Udyan

$= 15678 \times (0.83 \times 1) = 13012$ visitors/day

RCC for Silver Jubilee Park

$= 50713 \times (0.89 \times 1) = 63391$ visitors/day

STEP III- Effective carrying capacity (ECC) is defined as "the maximum number of visits that a park can sustain, considering the management capacity (MC). Management capacity further depends on the Management factors (Mf) and formulated as ECC = RCC × Mf_x. Values of management factors are given in Table 2. Therefore, ECC is RCC× Mf_1. In this study, one management factor (Mf_1) has been assessed by setting some parameters, and the result has been given:

$$ECC = RCC \times Mf_1 \qquad\qquad (3)$$

Where,

RCC= Real Carrying Capacity from equation (2)

Mf_1. =Management factor (Management)

ECC for Smriti Nagar Park

$= 5952 \times 0.8$

$= 4762$ visitors/day

ECC for Vivekanad Udyan $= 13012 \times 0.8$

$= 10410$ visitors/day

ECC for Silver Jubilee Park

$= 63391 \times 0.8$

$= 50713$ visitors/day

3. Results and Discussion
Analysis and Findings

The findings represent 15678 visitors in Vivekananda Udyan, 8267 visitors in Smriti nagar park, and 71226 visitors in Silver jubilee park can physically (and theoretically) visit per day, as shown in Table 4. However, admitting these many visitors in a single day is practically impossible. The PCC only provides a starting point for calculating the following levels of visitor carrying capacity. The PCC is a kind of assumption representing the number of visitors a place in a given time can retain. It can be said that PCC is a theoretical concept. In contrast, RCC is the actual value of PCC that estimates the physical capacity by considering some correction factors. The calculated result shows Silver Jubilee Park has the highest RCC value due to getting maximum weightage in PCC value and low level of limitation in correction factors. The RCC value of Silver jubilee parks is 63391 visitors /day, the highest compared to the other two urban parks. It means it is the highest range of capacity that can be allowed to these parks in a day, denoting the excellent capacity of this park. ECC of Smriti Nagar Park, Vivekanand Udyan and SJP is 4762, 10410 and 50713, respectively. The ECC value is more logical than the other two because it also considers visitors with the existing management capacity and conditions. The total value of ECC for these parks is 65885 visitors /day. It can be said that the carrying capacity of these parks is well preserved to adopt the higher level of yearly visitor advents. The calculated PCC, RCC, and ECC values are given in Table 3.

Table 3 Value of the Correction factor (Cf_1 & Cf_2) and Management factor (Mf_1)

Park Cf_x & Mf_x	1. Smiriti Nagar park	2. Vivekanand Udayan	3. Silver jubilee park
correction factor 1, Cf$_1$	0.72	0.83	0.89
correction factor 2, Cf$_2$	1.00	1.00	1.00
management factor 1, Mf$_1$	0.8	0.8	0.8

Table 4. PCC, RCC & ECC

S.NO	Park	Area (A) Sq.m	Area Required per person (Au) Sq.m	Daily Open period	Average time of visit/day	Rotation Factor	PCC	RCC	ECC
Park 1	Smriti Nagar Park	16121	9	6	1.3	4.6	8267	5952	476
Park 2	Appu Ghar/ Vivekanand Udyan	19401	9	8	1.1	7.3	15678	13012	1041
Park 3	Silver Jubilee Park	149575	9	6	1.4	4.3	71226	63391	5071

4. Conclusion

These findings provide a better understanding of parks, which may help understand public visitation. This method can be tested and validated in various recreational settings with various other factors in other geographical regions. Better factors can be chosen by comparing different parameters of different scenarios. All of these applications can be useful in designing parks. This not only broadens the use of mathematical methods in park visitor behaviour studies in the Indian context but it can also be applied in general research in all other parks such as national parls and zoo.

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