Assessment of the carrying capacity of the green spaces in Asansol city

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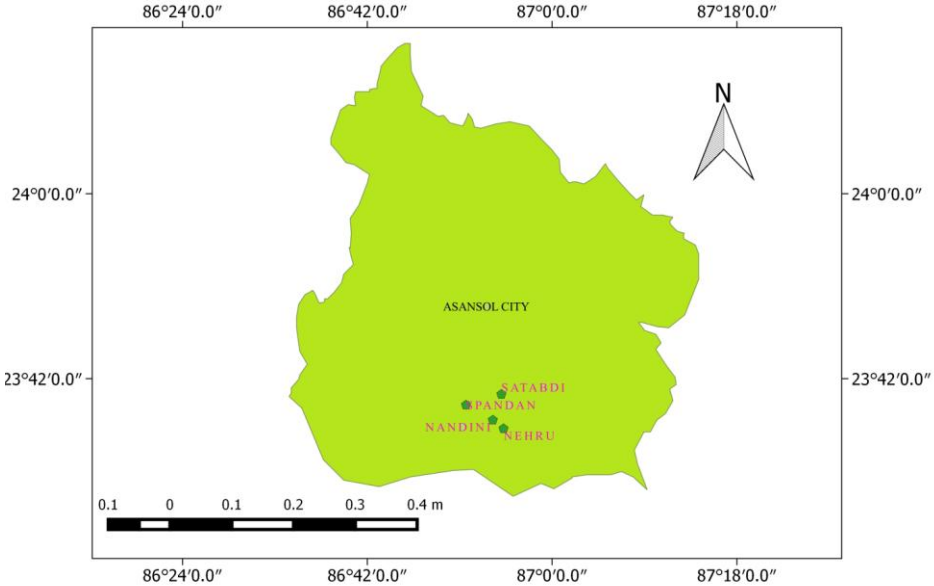
ABSTRACT *'urban environment' is a complex term considering all the social functions, climatic conditions taking place within urban area. Urban area always attracts human intervention for immediate access to facility and so consequently urban environment become vulnerable rapidly over the time. The Asansol city is no longer an exception to these conditions. The purpose of my research is to construct a frame work to examine functional ability of city's green space to cope with dynamic environment. For this application four well known parks of Asansol city (Nehru Park, Satabdi Park, Spandan Park, and Nandini Park) have been selected. These parks have been assessed through some mathematical equations. The resultant figure reveals that the Nehru Park and the Nandini Park have the highest and the lowest green space capacity respectively. The result also shows that these four parks have low sustainability to support city's population pressure and simultaneously concern about the per capita requirement of green space which is much below than requisite.*

Keywords: *Green space, ECCI, Functional capability, PCC.*

Introduction- Urban green space is a crucial term for city dwellers, particularly for those of the developing countries. Unexpected population growth, increasing migration, concentration economic growth, and unplanned urbanization create cities congested, polluted, and unhygienic. Urban green space serves a wide variety of ecosystem services that can solve many urban problems and improve city life. 'Urban green space' means public and private open spaces covered by vegetation which is directly or indirectly available for users (Haq, 2001) or Urban green space is a component of 'green infrastructure' is an important part of public open spaces and common services provided by a city can serve as a health promoting setting for all members of the urban community (WHO). Urban green space includes all the parks, gardens, playgrounds, maintained vacant areas. These green spaces have different sizes that depend on availability of lands. But in recent era creating open space or managing vacant space within city area is not an easy task because of growing land demand, increasing land values, and lake of proper planning. But green space should be an essential part of city planning to promote enormous environmental benefits which help to co-ordinate with climate change further. The green space improves air quality, diminution of urban heat island effects, filters carbon emission, recharges ground water, and keeps healthy bio-diversity. So availability of urban green space is an important indicator for city's well-being. According to WHO 9.5sq.m/ person is the minimum standard of urban green space for healthy living (kuchelmeister, 1998). Hence assessment of urban green space capacity is an essential to influence city planners, ecologist, and designers to add the green space in their planning schedules. The carrying capacity measurement technique for protected area was first developed by Cifuentes, 1992 and further it was applied by other researchers (caballeschers- lascurain, 1996, amadar et al.1996, cifuentes et al.1999, munar, 2002, Nghi al, 2007). The carrying capacity is the optimum number of population that can be supported by an ecosystem service without degrading the ecosystem. The carrying capacity of urban space is the base of integrating physical, socio-economic and environmental approaches. For sustainable urban planning, the foremost task is_to measure the environmental strength of cities environment. Keeping these objectives the main aim of present study is to calculate the carrying capacity of urban green spaces of Asansol city.

Study area - The study has been conducted in Asansol city, the second largest city of west Bengal after Kolkata, having population more than 5.63 lakh with density 4503/ sq.km as per 2011 census. The Asansol city is located in 23 degree 67 minute 39 second and 86 degree 95 minute 24 second covering almost125 sq.km. The city is lies under tropical climate experience, scorching summer with average 45°c temperature. The rainy season and winter season last for 4 months and 3 months respectively. The plateau topography of the city intensifies the hot season. As per statistics, the Asansol city is 39th worldwide and 11th growing urbanization city in India with the pace of 18.6% birth rate. The overcrowding population, increasing pollution, altering natural landscape through artificial constructions, climate variability has been considerably changing city environment. The growing urbanization and the environmental deterioration go hand in hand in this city degrading its healthy environment.

Fig-1 location map of study area



Source: prepared by author, 2018

Methodology- Asansol city has average number of public and private green spaces, but for present study only those well maintained public spaces which are frequently visited, have recreational facilities and are most effective for city environment have been consider. Asansol city has four recognizable parks named Nehru parks, Satabdi parks, Spandan Park, Nandini Park where city dwellers like to visit to these places. But the areas of these parks are not same. They have wide different among them in terms of area. So the parks areas are assessed as per Charles Downing Lay, (1914) guideline. As per his guideline, 1 large city parks has to have 400 acres land and 10 neighborhood parks have to have 250 acres space where population is 100,000 and population density is 8-1/3 persons per acre of city. In present context out of four mentioned parks the Nehru Park and the Satabdi Park have been recognized as large city parks and the Spandan Park and the Nandini Park have been recognized as neighborhood parks.

By applying Cifunet's (1992) formula, the three level calculation procedures (PCC, RCC, ECC) have been done to measure carrying capacity of Asansol city for each park-

First step- Physical Carrying Capacity (PCC) means the maximum number of visitors that can physically fit into the area in a given time. The formula of PCC is-

PCC= A/Au ×Rf (equation-1)

Where,

A- Available area of green space
Au- Area required per person
Rf- Rotation factor

And Rf is calculated by the following formula-

Rf= Daily open period/ average time of visit

The area of each of four parks has been measured during field survey and with the help of Google Earth software. The time period of each park slightly varies from each other that have been collected from park's staff members. The requirement of per capita space is determined as per WHO's (World Health Organization) standard that is 9.5 sq.m/ person.

Second step- Real Carrying Capacity (RCC): The maximum number of receivable visitors for the specific site. For RCC calculation, Correction Factors (CF) are required which has been obtained from the site's characteristics. RCC is measured by the following formula-

RCC= PCC× (Cf1×Cf2× Cf3×Cf4×…… Cfn) (equation-2) where,

PCC- Physical Carrying Capacity
Cf- Correction Factors

and the Cf is measured by the flowing formula-

CFx= 1- Lmx/Tmx (equation-2.1) where,

Lmx- Limiting magnitude of variable
Tmx- Total magnitude of variable

The correction factors are very essential to measure RCC. These factors are selected by considering site's environmental condition, management level, social and physical conditions etc. For the present study the correction factors for each park are- rainfall (Cf1), seasonal (Cf2), area of parks (Cf3) and park quality (Cf4). The uncongenial conditions of these factors can reduce the visitor's numbers and again their congenial conditions influence the visitors' advent to these sites. Therefore the different correction factors are explained below –

Rainfall (Cf1) - The Asansol city belongs to tropical monsoon climate experiencing heavy rain due to south-west monsoon from June to September. The average rainfall period in Asansol city lasts for four (4) months. So, heavy rainfall of these months is not suitable for the visitors. The limiting magnitude of this parameter is 122 days, and total magnitude of the variable is the number of days available for visitors in a year (365 days).

Cf1= 1-Lmx/Tmx
=1-122/365
=0.67

Seasonality (Cf2) - As the city belongs to tropical climate, the summer season is dominant prevailing almost 9 months or 273 days where the winter season prevails for only 3 months or 92 days from November to January. The period of winter season is the peak time for visitors and almost 9 months of the summer are restricted for visitors due to scorching heat. So the limiting magnitude for this parameter is 273 days, and total magnitude of the parameters is 365 days or days available to visit in a year.

Cf2 = 1-Lmx/Tmx
= 1-273/365
=0.25

Area (Cf3) - A large area with full vegetation cover has a good potentiality to diminutive urban heat island intensity. There is proportionate relation between large area and functional capability of a green space. The visitors also like large greenery space to spend time with friends and family. The limiting magnitude of the parameter is 64 acres, 5.13 acres, 2.94acres and 2.93 acres measured for each park and maximum magnitude of the parameter is 400 acres for first two parks recognize as large city parks and for next two parks is 25 acres each recognize as neighborhood parks (for 10 neighboring parks require space of 250 acres then 1 neighboring park require space of 25 acres).

Cf3= 1-Lmx/Tmx
Then for Nehru park is - 1-64/400= 0.84
Satabdi park is - 1- 5.13 /400=0.98
Spandan Park is - 1- 2.94/25=0.88
Nandini Park is - 1- 2.93/25= 0.88

Park Quality (Cf4) - park areas are used to spend the leisure time, where people get interacted with nature, feel relaxed from urban stress life. So park quality has a direct impact on visitor's satisfaction level. Park quality assessment has been done on the basis of field experience and interaction with travelers. The quality assessment concept has been taken from Nghi et al. (2007). But for present context this method has been changed slightly. The assessment result of park quality is given in table-2

Third step- Effective Carrying Capacity (ECC): The optimum number of visitors that a space can support within its available management capacity. ECC is the combination result of the management capacity and the real carrying capacity. ECC is calculated by the flowing formula-

ECC= RCC×MC1× Mc2× Mc3×Mc4…×Mcn (equation-3)

Where,
RCC- Real Carrying Capacity
Mc- Management Capacity

The management capacity (Mc) means the available conditions that need the park management authority to drive the functions and objectives. Management capacity depends on so many factors that vary according to parks' characteristics. In present study, four (4) variables have been considering- environmental condition (Mc1), social security (Mc2) management level (Mc3), legislation (Mc4). The base of management capacity is the perception of visitors that has been collected in field survey through series of questionnaire. Each of Mc parameters has been given the weightage as 1 mark and respondents have assessed out of 1. Not only these, many other articles have also been taken as reference to develop the management capacity concept. The value of the management capacity for each park is given in table-3.

Fourth step- Ecological Carrying Capacity Index (ECCI): The carrying capacity of a space estimates the functional ability to support existing population and their activities. Regarding the carrying capacity

concept, the ECCI was developed by Dong et al. (2011). The ECCI value denotes the ecological capacity regarding the population on the basis of ECC. ECCI value is calculated by the flowing formula-

ECCI= ECC/P (equation-4)

Where,
ECC- Effective Carrying Capacity
P- Population of urban unit (Asansol city)

The ECCI has index value where <1 means has not enough ecological capacity
>1 means has enough ecological capacity

Fifth step- It is important to calculate the area of green spaces required for Asansol city for healthy living. For that, first total green space per capita in this city has been calculated then the value was subtracted from total existing green space area of city. The area of existing green spaces (448807.8 sq.m. approx) within city area has been measured with help of Google Earth software. If the RGS value is ≤0 that means existing green space in city area is adequate to satisfy the WHO's standard or vice- versa.

TGS= N (Asansol) × STGS (equation-5)
=563917×9.5
=5357211.5 Sq. m.

Where,
TGS- Total green spaces required for habitant
N- Number of inhabitants in Asansol city
STGS- standard minimum green space area per capita according WHO 9.5 Sq. m/person

RGS= TGS-EGS (Equation-5.1)
= 5357211.5-448807.8 (approx)
= 4908403.7 Sq. m. (approx)

where,
RGS- Require green space area to be built in city area
TGS- Total green spaces required for city habitants
EGS- Existing green space area within city area

Result and discussion- In order to find out green space status of Asansol city it is necessary to assess the existing green space capacity of the park and required space to carry anthropogenic pressure of the city through aforesaid mathematical formulas. Table-1 shows the area of four mentioned parks with their extension out of which first two are large city parks and next two are neighborhood parks.

Table1. Area coverage of parks of Asansol city

SL NO	Name of the Park	Total Area (Sq. m)/ Acres (approx)	Latitude	Longitude
1	NEHRU	258999.04/64	23°38'04''	86°56'28''
2	SATABDI	20760.39/5.13	23°41'34''	86°57'33''
3	SPANDAN	11897.76/2.94	23°41'23''	86°52'56''
4	NANDINI	11857.29/2.93	23°41'8"	86°55'01''

Out of four parks, Nehru park covering large extension of area located slightly outside from the city interior beside the Damodar River possesses a great aesthetic beauty. The Satabdi Park and the Spandan Park have much interior location restricting their geographical extension. Of cifuentes's three level mathematical approach, correction factors act as auxiliary factors. The correction factors (Cf) are the combination of environmental, social and physical conditions, a vital indicator as it can influence and also restrict visitor's advent on the site reflecting the qualitative and the functional capability of a place. In present context four correction factors (rainfall cf1, seasonality cf2, area cf3, park quality cf4) has been assessed by setting some parameters and the result has been given in table-3.

The assessment of park quality (Cf4, table-2) shows two common things that all the parks are suitable for recreational activities and has good vegetation coverage which denotes quality of the park. The two parks have high pollution level (Satabdi Park & Spandan Park) in comparison with others two because of location in congested area. The Nehru Park has best background as the Damodar River passing by the park brings scenic beauty. Out of four parks The Nehru Park, the Satabdi Park and the Nandini Park are good in park quality assessment.

Table2. Park quality indicators of Asansol city ('+' Good or Suitable condition, '-' Bad or Unsuitable)

Name of the Park	Site Background	Vegetation Coverage	Pollution level	Recreation Facilities	Transport Connectivity	Park Quality	Correction factor
NEHRU	+	+	+	+	-	1/5	0.8
SATABDI	+	+	-	+	+	1/5	0.8
SPANDAN	-	+	-	+	+	2/5	0.6

NANDINI	+	+	+	+	-	1/5	0.8

Table3. Data sheet of rotation factors, correction factors, management factor

Name of the Park	Rotational Factor(Hours)	Correction Factors				Management capacity			
		Cf1	Cf2	Cf3	Cf4	Mc1	Mc2	Mc3	Mc4
NEHRU	6	0.67	0.25	0.84	0.8	0.6	0.4	0.5	0.2
SATABDI	4.5	0.67	0.25	0.98	0.8	0.4	0.4	0.4	0.2
SPANDAN	6.5	0.67	0.25	0.88	0.6	0.4	0.4	0.5	0.2
NANDINI	6	0.67	0.25	0.88	0.8	0.5	0.4	0.3	0.2

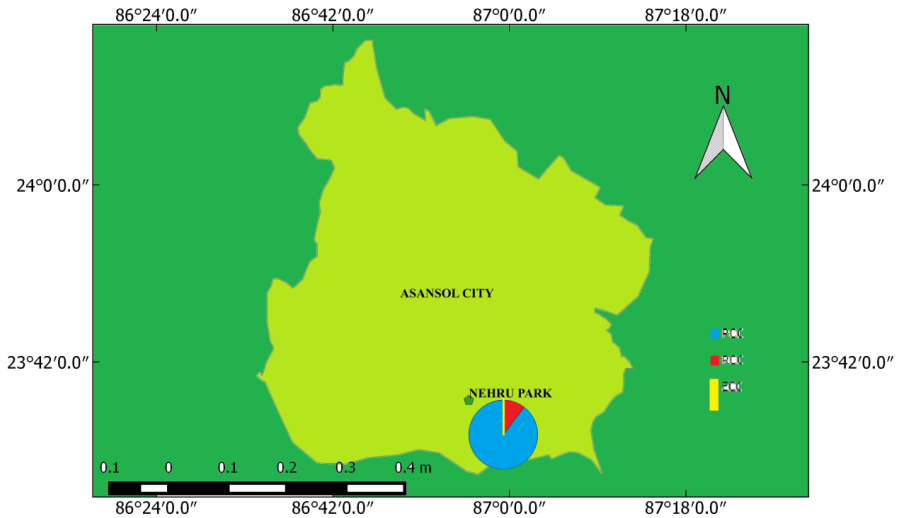
The variation in management capacity (Table-3) among these parks is slight. Some different have been observed in environmental condition & management level. As the Nehru Park and the Nandini Park are located outside of city area, free from crowd and sound stress brings calm and quiet atmosphere. The staff members of the Nehru Park and the Spandan Park show great effort to beautify and make noticeable their park to satisfy the visitors. The physical carrying capacity is a kind of assumption number of visitors that can be retained by a place in a given time. It can be said physical carrying capacity (PCC) is theoretical concept but real carrying capacity (RCC) is actual value of PCC that estimates the physical capacity by considering some correction factors. The calculated result shows Nehru Park has the highest RCC value due to getting maximum weightage in PCC value and low level of limitation in correction factors. The total RCC value of mentioned parks is 21306.78visitors /day. It means it is the highest range of capacity that can be allowed to these parks in a day, denoting towards good capacity of these parks. The ECC value is more logical than others two because it considers the visitors with the existing management capacity and conditions. The total value of ECC for these parks is 480.51visitors /day. It can be said that the carrying capacity of these parks is well preserved to adopt the higher level of yearly visitor's advents. The calculated PCC, RCC, ECC values given in table-4 and theses values are adjusted with the city population by Bar Diagram (fig-7). Therefore PCC, RCC, ECC values contribute 34%, 4% and less than 1% respectively to the total population.

Table4. Data sheet of PCC, RCC, ECC

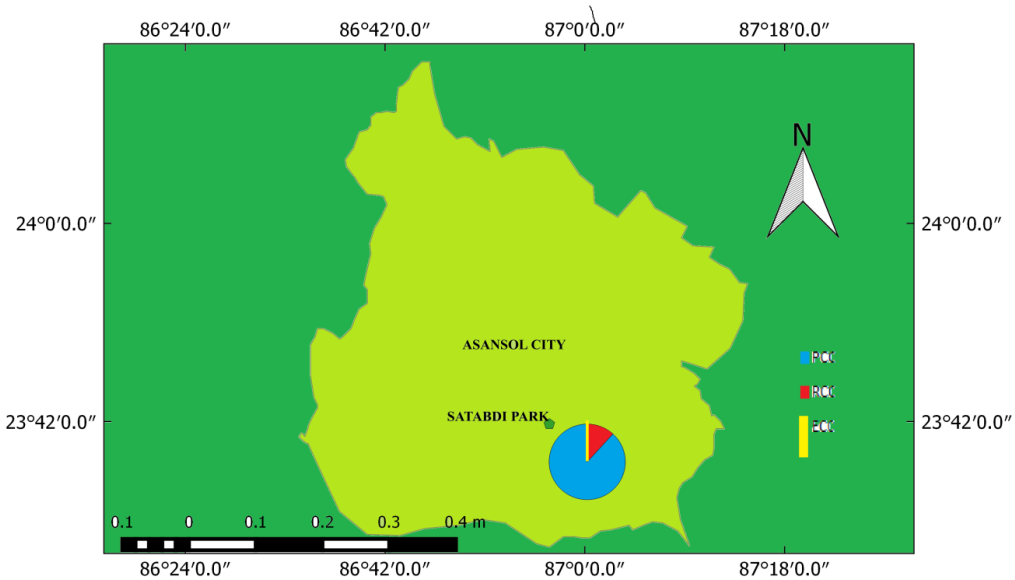
Name of the Park	Physical carrying capacity	Real carrying capacity	Effective carrying capacity
NEHRU	163578.34	18412.37	441.89
SATABDI	9833.86	1291.38	16.52
SPANDAN	8140.57	719.95	11.51
NANDINI	7488.82	883.08	10.59
Total	189041.59	21306.78	480.51

Fig-2 Representation of PCC, RCC, ECC values of these four parks cartographically.

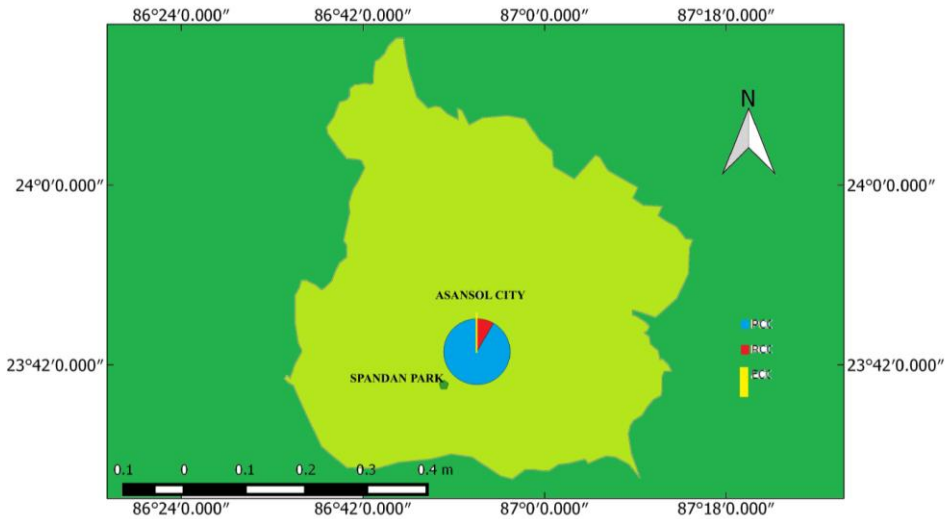
NEHRU PARK



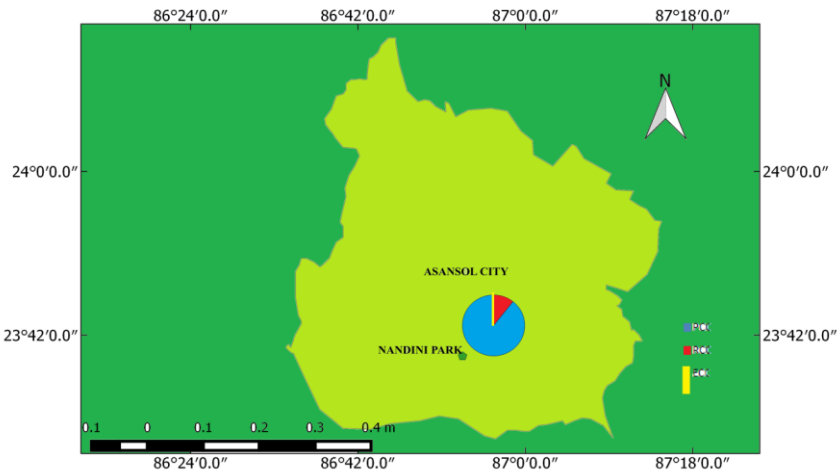
SATABDI PARK



SPANDAN PARK



NANDINI PARK



Source: prepared by author, 2018

Fig-3 Image of parks

NEHRU PARK SATABDI PARK

SPANDAN PARK NANDINI PARK

Source: captured by author

Considering the anthropogenic pressure within city area some other calculation procedures have been done to easily understand the real status of city's environmental strength including Ecological Carrying Capacity Index (ECCI). The ECCI measure the sustainability of urban green space to support population pressure. The value ECCI of these parks is below 1 which means these parks have not enough ecological strength to support existing population pressure. The result is given in table5

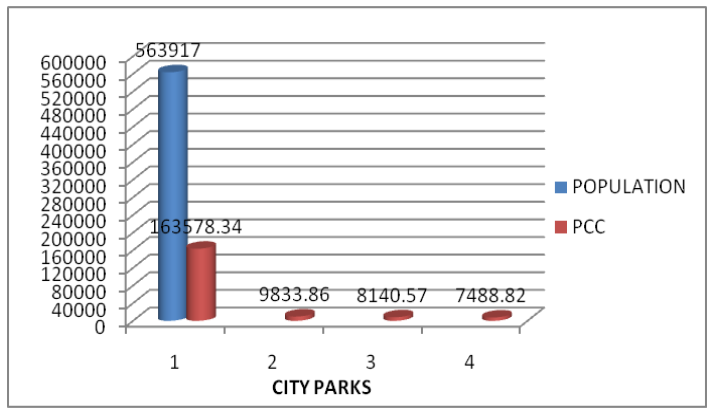
Table5. Data sheet of ECCI

Name of the Park	Effective Carrying Capacity	City population	Ecological carrying capacity	Class
NEHRU	441.89	563917	00007.83	Low
SATABDI	16.52	563917	000002.92	Low
SPANDAN	11.51	563917	000002.04	Low
NANDINI	10.59	563917	000001.87	Low

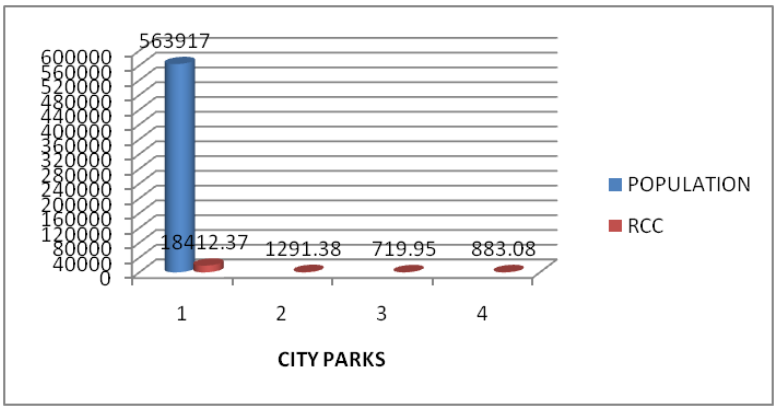
Another mathematical procedure has been done to understand the required amount of green spaces that has to be set up. The resultant value is 4908403.7 sq. m (approx) which is much higher than index value. It is proved that Asansol city is suffering from shortage of green space requirement.

Fig.4 Scaled adjusting a) PCC, b) RCC, c) ECC values of each park (1. Nehru Park, 2. Satabdi Park, 3.Spandan Park, 4.Nandini Park)with city population

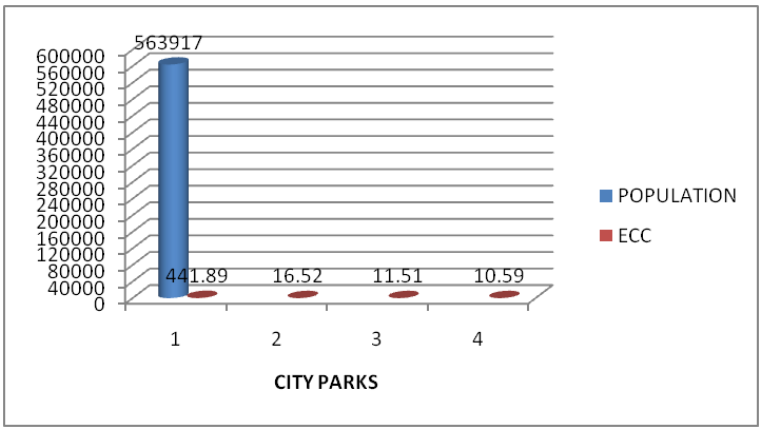
a)



b)



c)



Source: prepared by author, 2018

Conclusion-The main focus of the present study is to measure the green space capacity of Asansol city. The three level conventional methods of Cifuentes's have been applied to measure the functional capability of these parks. It is very vital for the congested city to detect environmental capability for sustaining healthy living. The growing anthropogenic pressure within city area has several adverse affects on environment. The present investigation shows that each green space has certain capacity that depends on management power, infrastructure development which varies with space and time. After certain mathematical procedures the result shows that recreational capability of the four parks is well preserved. But the ecological strength of these parks respect to the city's population is in vulnerable condition. The per capita green space availability in this city is in inferior stage. Implementing proper initiatives, arranging more green spaces and co-operation of the city dwellers will enhance the functional ability of these green spaces and environmental strength of the city in future.

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