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Park System Concept for Environmental Sustainability in Bengaluru, Karnataka

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Abstract: ***Urban Park System, one of the most important components of cities is an integrated concept between natural and automatic system, which exigencies balance. These park system play an multitude role in urban life by offering social, economic and environmental benefits to the urban residents. Climatic amelioration, hydrological cycle, biodiversity, sustainability and noise screening are some of the important environmental benefits provided by these parks. Urban parks play an important role in protecting and promoting biodiversity by providing various habitats for flora and fauna, especially common bird and animal species (Chiesura, 2004; Cornelis and Hermy, 2004; Millennium Ecosystem Assessment, 2005). Urban Parks are essential to the resilience of urban space structures and there is prerequisite to build an integration between the ecological, social, economic, aesthetic aspects of urban landscape architecture. Surveillance of Bangalore problem was obtained based on literature, distinctive and prospective analyses and methodology was developed based on an approach to urban issues and its relation to the urban park system. Bangalore with its salubrious climate, once called garden city has numerous lakes and gardens developed since Kempegowda's (Builder of city) time and later by colonial people. The present study mainly focused on urban parks, because of the significant contribution of parks in urban environment, identity and control of urban growth in terms of balance between conservation and development. Ten parks were selected for the study in various parts of the Bengaluru and were first evaluated for total number of plants and families to which it belongs. In the second stage environmental benefits were examined according to 5 main criteria and 14 parameters. Among ten parks three of them with its vast area and plant diversity is found to be significantly contributed to the environmental sustainability of the city.***

1. Introduction

Park culture was introduced during British occupation, which gradually integrated into Indians through influence of educated and elite (Ramachandra et al 2014). Unprecedented and large scale urban land use change of green areas in Bengaluru has resulted in the environmental imbalance of the city. The excessive carrying capacity is the main problem for Bengaluru. Overlapping issues like water, air and soil pollution, overcrowding, flooding of low lying areas during rainy season has created a network of problems. All these problems can be resolved if city authorities acts in a systematic manner through urban park system.

In modern landscape architecture, the park system is collaborating with the idea of planning greenways, which run through urban and rural areas. These systems can serve the landscape through ecological, recreational, social, cultural, and healthful measures and are designed with intentions of sustainability (Muller et al 2013). Urban Park System is an important part of the environmental support systems, which should be evolved to promote green infrastructure in urban and peri urban areas. Social dimensions of carrying capacity include habits, hygienic and controlled resource distribution, the disproportion private and social costs, the difficulty in formulating rational policy in the face of uncertainty. Integrated urban park system will enhance the multifunctional role, connectivity, habitability, durability, identity and investment. (Uniaty 2018 *IOP Conf. Ser.: Earth Environ. Sci.1***06** 012044). Urban parks are essential for liveable and sustainable cities and are a part of complex urban ecosystem network and have aesthetic, healthy, recreational, economic and environmental benefits for urban communities (Grahn, 1985; Burgess et al., 1988; Nowak and Dwyer, 1996; Blum et al., 1998; Conway, 2000; Gehl and Gemzoe, 2001)

The contribution of urban parks to climatic amelioration is that trees create shade and other vegetation helps to reduce temperature and cool urban areas by evapotranspiration (Nowak et al., 1998; Cummins and Jackson, 2001; Sherer, 2006). The heat island effect is reduced, humidity levels are increased, and the microclimate of urban areas is improved (Millennium Ecosystem Assessment, 2005). Permeable surfaces and vegetation of urban parks capture rainfall and give it to the atmosphere with evaporation and transpiration. Urban parks support water management (Konijnendijk et al., 2013) by providing storm water/flow regulation (reducing the amount of storm water flow) and help to prevent floods by absorbing excess water.

Many studies have shown that urban parks have the potential to reduce the negative effects of urbanization, such as improving microclimate conditions, reducing noise levels, transforming cities into better quality environments (De Ridder et al., 2004; Lam et al., 2005; Feliciano et al., 2006 Schnell et al., 2012). Urban parks can offer a temperature drop of up to 4 °C with the cooling effect (Givoni, 1991; Avissar, 1996; Spronken - Smith and Oke, 1998; Shashua - Bar and Hoffman, 2000; Jonsson, 2004; Zoulia et al., 2009). Daytime temperatures in large parks are 2 - 3°C lower than in the surrounding streets (Sadeghian and Vardanyan, 2013).

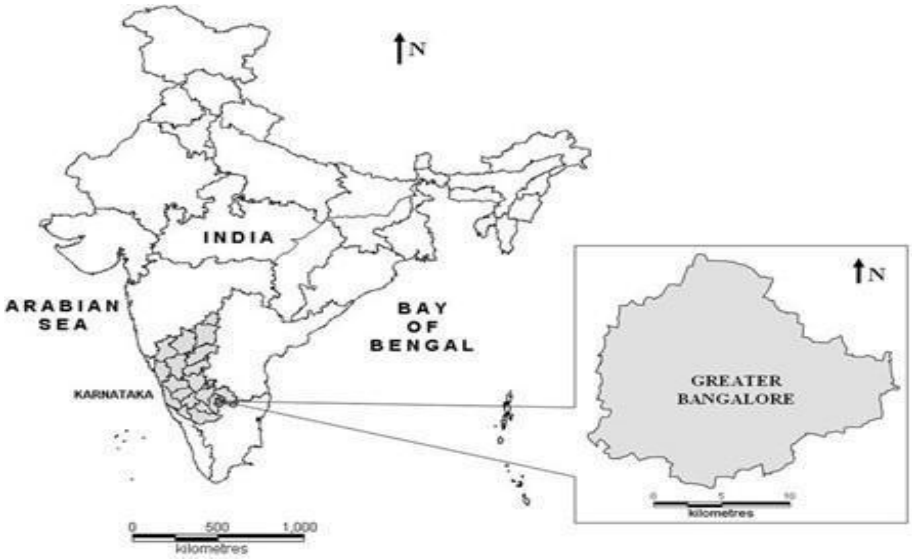
Assessment of the environmental benefits of urban parks can promote the conservation of urban green spacesand offer solid scientific evidence for urban park management (Xie et al., 2019). The current investigation mainly focussed on the role of urban parks in maintaining climate, biodiversity and environmental sustainability of the Bengaluru city by concentrating on some important parameters.

2. Methods

Study Area

Bruhat Bangalore Mahanagara Palike (BBMP) /Greater Bangalore is located between latitude parallels of 12°39'00'' N & 13°1'00" N and longitude meridians of 77°34'50.31" E and 77°58 '06.43" E at an average elevation of 900 mts above mean sea level and has an area of 741 sq Km and supports 1.3 crore population.

Ten parks with different dimensions were selected for the study in various parts of the Bangalore. Parks were first evaluated for total number of plants and families to which it belongs. In order to investigate the environmental benefits of urban parks they were examined according to 5 main criteria and 14 sub criteria belonging to the main criteria (Table 1).



The scores of the main criteria of the parks were determined by taking the average of the scores of the sub - criteria. Environmental benefits of these ten parks were found by taking average of Main criteria. Parks were classified on a 5 - point, according to their scores as Very poor: 0 - 0.6; Poor: 0.61 - 0.70; Fair: 0.71 - 0.80; Good: 0.81 - 0.90; Very good: 0.91 - 1. Then, the data were interpreted by creating tables.

3. Results

The present investigation was carried out in 10 Parks located in different zones of Bangalore. Konana kunte park showed highest plant diversity followed by the Dasarahalli Lake park and Jaraganahalli Park. Lowest plant diversity was found in the Malleshwaram Park (Table 1)

Table 1: Plant Dominance and Diversity Of plants in different Parks:

S. No	Name of the Parks	Number of Species	Number of Families
1.	Dasarahalli Lake Park (DLP)	25	17
2	Malleshwaram Park (MP)	10	09
3	Chandanavalli Thota (CT)	15	11
4	Jayanagar Mini Forest (JMF)	17	9
5	Jaragana Halli Park (JP)	19	13
6	Konana Kunte Park (KKP)	21	14
7	Lakshmana Rao Udhyanavana (LRU)	18	10
8	Nataraja Park (NP)	23	15
9	Raj Guru Park (RP)	17	13
10	Kuvempu Park (KP)	18	12

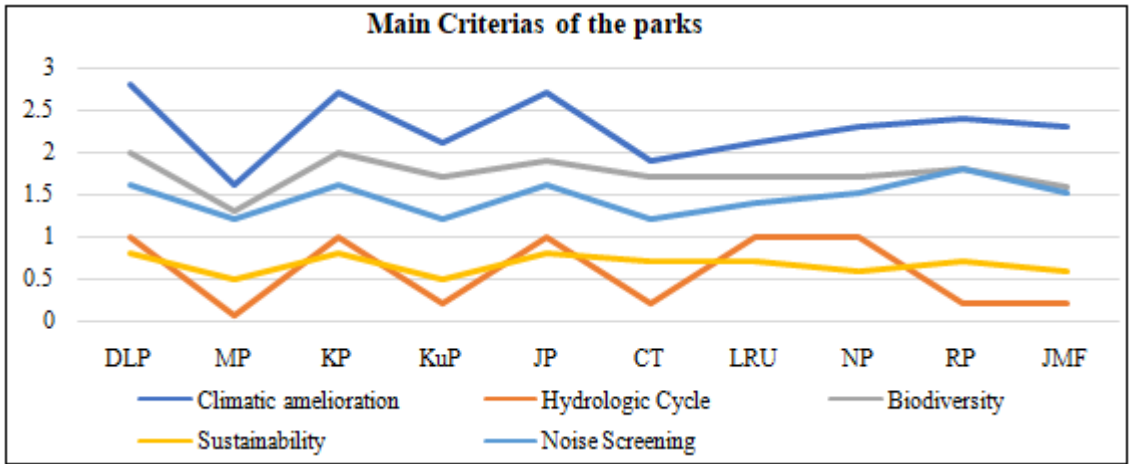
In Table 2. For environmental benefit score, the observations were mainly focused on fourteen sub criteria and five main criterias like Climatic amelioration, Biodiversity, Hydrologic cycle, Sustainability and Noise Screening. Basing on this, environmental benefits scores were calculated for these parks.

Among the 10 parks, Malleshwaram Park was found inadequate with respect to sub - criteria "percentage of vegetation" in the main criteria "Climatic amelioration". In terms of "canopy ratio" and "woody plant coverage ", Malleshwaram park, Kuvempu park, Lakshman Rao park and Chandanavalli thota were "deficient". "Amount of Impermeable surface" under the main criteria "Hydrological cycle", was high both in Malleshwaram park and Lakshman Rao park. High permeable surface was found in Dasarahalli lake park followed by Jargana Halli and Konana Kunte park. There was no "water collection systems" in any of the observed ten parks. When the parks were evaluated in terms of "presence of plants", which is one of the sub - criteria of "Biodiversity", it was seen that all the parks had plant existence. Varieties of Birds and small rodents like squirrel and Rats were more in all parks when compared to build up areas. Deepalakshmi and Salomi (2019) observed similar decrease in sparrows population with increased urban development. Jayanagar Mini forest, Chandanavalli Thota, Lakshman Rao park, Dasarahalli lake park showed "networks" between nearby green spaces. Nataraja Park, Rajguru Park and Jayanagar Mini Forest contained higher number of "invasive plants". All parks are at "satisfactory" level in terms of "amount of open space per person", which is includedin the sub - criteria of "Sustainability". While all the parks support "native flora", "regionally produced compost" is not used in any park.

Table 2: The state of the main criteria and sub - criteria of the Environmental Benefits of the Ten parks

Main Criteria		Sub Criteria	DLP	MP	KKP	KP	JP	CT	LRU	NP	RP	JMF
1	Climatic amelioration	Percentage vegetation	0.9	0.5	0.9	0.7	0.9	0.7	0.8	0.8	0.8	0.8
		Canopy ratio	1	0.6	0.9	0.7	0.9	0.6	0.7	0.8	0.8	0.8
		Woody Plant Coverage	0.9	0.5	0.9	0.7	0.9	0.6	0.6	0.7	0.8	0.7
2	Hydrologic Cycle	Amount of Impermeable surface	0.2	0.6	0.2	0.3	0.2	0.3	0.2	0.2	0.3	0.3
		Amount of Permeable Surface	0.8	0.4	0.8	0.7	0.8	0.7	0.8	0.8	0.7	0.7
		Presence of water Collection System	-	-	-	-	-	-	-	-	-	-
3	Biodiversity	Presence of Flora	0.9	0.4	0.9	0.6	0.8	0.7	0.7	0.7	0.8	0.6
		Presence of Fauna	0.9	0.4	0.9	0.6	0.9	0.7	0.7	0.6	0.7	0.6
		Presence of invasive plants	0.2	0.5	0.2	0.5	0.2	0.3	0.3	0.4	0.3	0.4
4	Sustainability	Presence of Native plants	0.8	0.5	0.8	0.5	0.8	0.7	0.7	0.6	0.7	0.6
		Use of regionally produced compost	-	-	-	-	-	-	-	-	-	-
		Use of recycled materials	-	-	-	-	-	-	-	-	-	-
5	Noise Screening	Height and Density of woods and Bushes	0.9	0.5	0.8	0.7	0.8	0.7	0.7	0.8	0.9	0.7
		Protection against winds	0.7	0.5	0.8	0.7	0.8	0.6	0.7	0.7	0.9	0.8

Except Malleshwaram park all other parks were “adequate” in terms of “height and density of wood and bushes”, one of the sub - criteria of “Noise screening”. There is “protection against wind. No noise screening was constructed with "construction materials" in any park (Table 1). In the present study, many areas surrounding the parks seems to had cooler climate in terms reduced dust, heat and lively ambience. This is in line with study made where they found the contribution of urban parks to climatic amelioration by reducing temperature and cool urban areas by evapotranspiration (Nowak and Dwyer, 1996; Blum et al., 1998; Nowak et al., 1998; Cummins and Jackson, 2001; Sherer, 2006; Konijnendijk et al., 2013). The heat island effect is reduced, humidity levels are increased, and the microclimate of urban areas where the temperature is higher than the environment because of dense buildings is improved (Millennium Ecosystem Assessment, 2005; Sadeghian and Vardanyan, 2013).



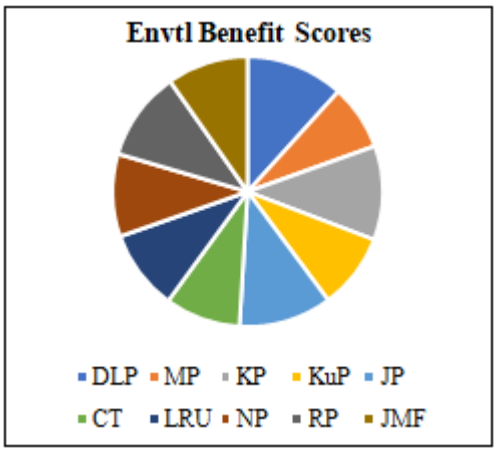
Graph 1: Main criteria scores of Environmental Benefit in the parks

Graph 1. Reveals main criteria scores of ten parks. Among the ten parks are examined in terms of main criteria, 3 of the 10 parks observed are "Very good" interms of "climatic amelioration" (Dasarahalli Lake Park, Jarganahalli park and Konanakunte park), Rajguru park fell under "Good" category, Lakshman Rao park, Nataraja Park and Jayanagar Mini Forest, Kuvempu and Chandanavalli thota fall under fair category, while Malleshwaram Park was “Poor”. Similar observation was made by Barış Kara and Yasin Aşık (2022) in their study on urban parks of Nazilli District, Turkey. In terms of "Hydrological cycle", 3 parks were evaluated as good ie., Jaraganahalli, Konana kunte and Dasarahalli lake park, 3 parks were evaluated as "Poor" (Chandanavana Thota, Rajguru and Malleshwaram Park) and the remaining four parks were fell under fairer category.

When the parks are evaluated in terms of “Biodiversity”, 3 parks are good like Jaraganahalli, Konana kunte and Dasarahalli lake park. Nataraja Park was falling under fair category while Kuvempu and Malleshwaram fell under poor category.

In terms of “sustainability”, Dasarahalli lake park falls under very good category, 6 other parks are “Good” (Konana kunte park, Nataraja, Rajguru park, Lakshman rao park, Jaragana halli park and Chandanahalli thota), 3 parks are falling under “Fair” category (Kuvempu, Malleshwaram park, Jayanagar mini forest).

Looking at the "Noise screening" scores, 1 park Dasarahalli lake park with large number of tall trees fell under very good category.4 parks are "Good" (Lakshman rao park, Nataraj park, Konan kunte park and Raj guru park), Remaining 4 are fair category and Malleshwaram park falls under poor category.



Graph 2: Environmental Benefit Scores of parks

Graph 2. shows the Environmental benefit Scores of ten parks. Environmental benefit scores, calculated by taking average scores of 5 main criteria, revealed prime comparison between different parks in terms of overall environment. Dasarahalli lake park and Jaraganahalli park fell under good category under this parameter, while Lakshmana Rao Park and Konana kunte park are at "fair" level. None of the parks fell under very good category. Among the Ten parks, Dasarahalli Lake Park showed the highest environmental benefits score and the Malleshwaram Park revealed the lowest.

4. Conclusion

The present investigation concluded that, the studyarea is highly urbanized with lot of developmental activities like metro construction, road widening etc.,, In order to increase the environmental benefits of parks in Bengaluru, sub - criteria of "climatic amelioration", "hydrological cycle", "biodiversity" and "sustainability" should be improved. The main criteria "noise screening" should show more number of tall trees especially at the border of the parks. It is stated that urban parks can clean the air, improve the microclimate within their boundaries and reduce noise (Cohen et al., 2014). In order to increase the contribution of the parks to the "climatic amelioration", the "percentage of Native vegetation" should be increased in these Parks and the "canopy ratio" and "woody plant coverage" should be increased in the Malleshwaram and Kuvempu park. For this, native plant species compatible with the Bangalore climate like Pongamia pinnata, Azadirachta indica, Pterocarpus marsupium, Terminalia catapa, Lagerstromium and similar spp should be planted. In order to improve their contribution tothe "hydrological cycle", the "ratio of permeable surface" should be increased in Malleshwaram park and Chandavalli Thota and "water collection systems" should beestablished in all parks. For this, permeable surfaces that allow rainwater harvesting should be protected and increased. In order to improve their contribution to "Biodiversity", "presence of faunal population like Insects, small animals and birds" should be increased by planting trees like Pongamia pinnata, Azadirachta indica, Ficus spp and Terminalia catapa etc. In Lakshman Rao park and Chandanavalli thota, the "presence of invasive plants" should be reduced. Native plant species that can attract local fauna should be given priority instead of these species. Parks fulfill maintaining, restoring and enriching the native flora and fauna, as well as protecting and improving the natural environment (Rakhshandehroo et al., 2017). High and densely textured native trees and shrubs should be used in "noise screening". "Wind screening" should be created, comprising species with deep roots and strong stems in the prevailing wind direction. In narrow areas where plant materials such as trees and shrubs cannot be used for noise screening, "construction materials" should be used for this purpose. Parks in urban areas are natural buffers for stabilization of the urban ecosystem. So, careful planning is required to get maximum benefit from urban greenspaces and parks (Hussain et al., 2010).

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