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Re-examining the status of public open spaces for achieving smart city goals in Prayagraj, India: Reality versus expectations

Roohi Rawat, Uttar Pradesh; Avijit Sahay*, Uttarakhand; Amrita Bajaj, Delhi

Abstract

Smart City Mission is a major initiative of the Government of India to transform Indian cities according to global standards of well-being and quality of life. One of the major provisions of the mission is to provide parks, green spaces, and open spaces (together termed as Public Open Spaces or POS) in Indian cities. Prayagraj is one of the first 100 cities selected under the mission for development as a smart city. In the current study, we have tried to assess the current status of Public Open Space in Prayagraj with the help of remote sensing and fieldwork data. The result thus obtained is then compared with global and Indian standards to understand how much Prayagraj lags behind other cities. This is done to understand the challenges that the Smart City Mission faces in making Prayagraj a smart city with a world-class urban green environment. The study shows that the current status of Public Open Space is very poor in Prayagraj. The city not only lags behind other world and Indian cities in terms of per capita availability of Public Open Space and percentage of area under Public Open Space but also falls short of the minimum required value of both these measures as recommended by United Nations-Habitat and World Bank.

Keywords: *Prayagraj, smart city, public open space, urban green environment*

Introduction

Prayagraj, formerly called Allahabad is a major city and urban agglomeration in the Indian state of Uttar Pradesh. The city has been identified as one of the 100 cities across India that is to be developed into a smart city under the Smart City Mission of the Government of India. As part of the Smart City Mission, Prayagraj is set to receive ₹ 10 billion (Phadke, 2016) (approximately $ 125 million in 2022 prices) for various development projects related to 10 core elements that are to be developed. One of these core elements under Smart City Mission is a sustainable environment. The goal of a sustainable urban environment under the Mission is to control and reduce the carbon dioxide footprint in the city with the help of green infrastructure and the development of parks and green spaces within the city (Smart City Mission, n.d.). The mission statement also clearly says that adequate provision of parks and open spaces in Indian cities is a major objective of the mission.

While there can be many different classes of land use that can be called green spaces, the World Health Organisation (2017) has defined urban green spaces as open space areas and areas reserved for parks in an urban

environment. Collectively, all these can be called Public Open Spaces (hereafter POS). Using this definition of urban green spaces as POS, we have in this paper made an attempt to assess the current state of the public open space in Prayagraj. While no threshold has been recommended in the Smart City Mission to reach a particular level of availability of POS, we have calculated the per capita availability of POS and the percentage of area covered by POS in different zones of the city. This is then compared with the global average and globally expected level of POS for achieving environmental sustainability in the city. With the help of these, we have tried to analyse the challenges ahead in transforming the urban environment and completing this element of the Smart City Mission in Prayagraj.

Public Open Spaces (POS)

According to the Environmental Protection Agency (n.d.) of the United States of America, *"Public Open Space is any open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public"*. Carr *et al.* (1992) in similar terms have defined POS as general places of public accessibility. Woolley (2003: 205) also calls POS "an outdoor area which is open to freely chosen and spontaneous activities, movement, or visual exploration".

There has been growing interest in POS research due to the evidence that nature positively impacts human wellbeing (Frumkin, 2013; Taylor & Hochuli, 2015). This is especially important in cities, where both social and ecological components, together with green spaces are under stress as a result of urbanisation (Taylor & Hochuli, 2017). In this context, it is imperative to conduct comparative research in order to understand the variation in the definition of POS around the world (Niemelä, 2014).

There are a number of reviews published on specific aspects of POS. This includes a synthesis of 219 research papers on human environment interactions in urban green space (Kabisch *et al.*, 2015), a meta analysis of 25 studies on the health benefits of POS (Bowler *et al.*, 2010), and a review of 25 studies on the health benefits of green spaces (Hunter & Luck, 2015). Green infrastructure is a related term in the literature that refers to a network of POS on a city or landscape wide scale that serves urban residents (Tzoulas *et al.*, 2007). Other terms that are closely related to POS include urban vegetation, parks, remnant patches, residential gardens or yards, and road verges or streetscapes. All of these terms and definitions assume human interaction in a city setting (Taylor & Hochuli, 2017). Scholars proposed some significant characteristics of a good POS, such as connecting people to nature (Parra Saldívar, *et al.*, 2020), encouraging active and passive activities (Woolley, 2003), granting freedom of action and access (Carr, *et al.*, 1992; Bahriny & Bell, 2021), promoting leisure and recreational facilities, and offering a stage for public art and performance (Whyte, 1980).

POS has been considered an inalienable element in the maintenance of public health and urban planning in recent years (Kwon, O. H., *et al.*, 2021). POS such as parks, gardens, street trees, river sides, and playgrounds improve mental and physical health (De Vries, *et al*, 2003; Gascon *et al*, 2015; Dadvand *et al*, 2016). As a result, global policy changes and efforts have been made to provide more POS in order to create a sustainable and comfortable living environment

As shown in the preceding paragraphs, POS constitutes a very important element of any urban dwelling. Since urban areas are devoid of agricultural lands and forests (Whitford *et al.*, 2001), and have very little and sometimes no natural vegetation (Sharpe *et al.*, 1996), these patches of greenery, plantation, and open spaces provide an ecological element to an otherwise dense built-up area. They help in maintaining a healthy environment within the city. Furthermore, POS also absorbs a large amount of carbon dioxide emissions from urban vehicles, households, and industries (Marchi *et al.*, 2015; Nastiti and Giyarsih, 2019). They also provide aesthetic pleasure to the inhabitants and serve as playgrounds for kids and adults alike. POS is home to many birds and small animals that would otherwise have no habitat in the city, enhancing the biodiversity quotient in a city (Hermy, 2010).

However, with the rapid increase in population and densification processes in urban areas, cities have lost POS and biodiversity mainly in Asia and Australia, and to a lesser extent in Europe and North America (Haaland & Bosch, 2015). With the growing frequency and intensity of environmental hazards and climate change such as global warming, urban design initiatives will play a key role in decreasing risk, improving health, and strengthening resilience (Stone, *et al.*, 2010).

Research on POS in India is of more recent origin if not absent. The large urban agglomerations have received some attention. Studies on POS have been conducted from various perspectives such as the environmental impact on POS in Chennai (Sundaram, 2011), environmental attributes of POS in Pune (Budruk *et al.*, 2009), urbanisation impact on POS in Bangalore (Bharath *et al.*, 2018), growing and preserving POS and green cover in Bangalore (Nagendra et.al., 2012) and so on.

In the current study, we have tried to find out the location, spread, and per capita availability of POS in Prayagraj and compared the result with global standards of POS availability.

Study Area

Located at the confluence of Rivers Ganga and Yamuna in the north-central Indian state of Uttar Pradesh (Fig. 1), Prayagraj is a major urban centre of the middle Ganga plain. The city of Prayagraj (as per the Prayagraj Municipal Corporation) extends from 81° 43′ 20″ E to 81° 53′ 30″ E longitudes and from 25° 23′ 00″ N to 25° 32′ 00″ N latitudes. From east to west, the city limit is about 25.2 km, and from north to south, the city stretches for about 30.5 km. The total area under the Corporation is 75.6 km^2. It is located at an altitude of 98 m above the mean sea level.

The Census of India 2011 has classified the city of Prayagraj into three divisions namely the Prayagraj Municipal Corporation, the City Out Growths, and the Prayagraj Cantonment Board (CB). The city limits of Prayagraj come under the Municipal corporation which is approximately 75.6 km^2 (excluding the Cantonment area and outgrowths). It has been divided into 80 wards for administrative convenience. Its total population is 11,12,544 persons (2011 Census) excluding the Cantonment area and Out Growths. The urban expansion and development of the city in the municipal limits is intercepted by the presence of cantonment areas. These cantonment wards are military residential areas and beyond civil

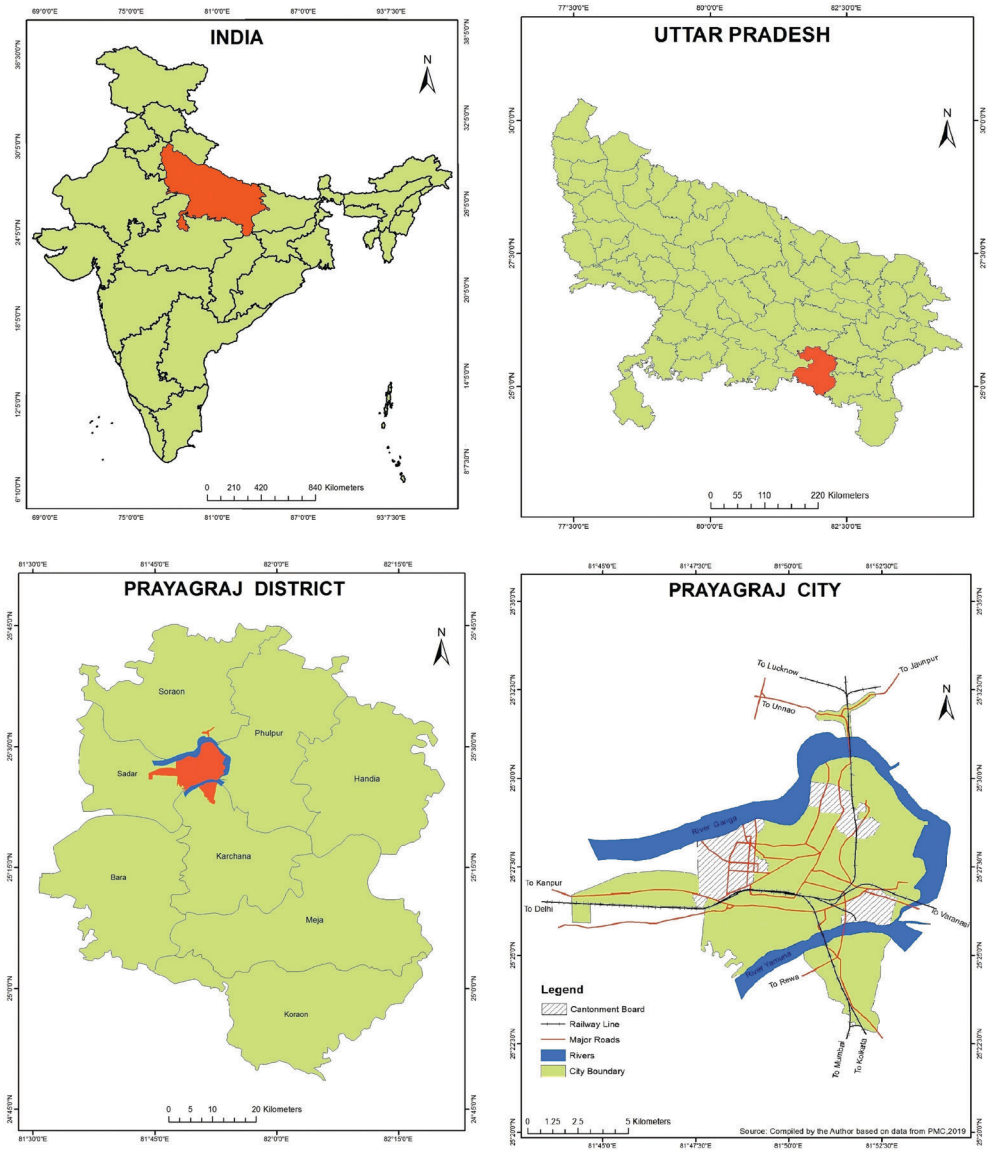

Fig. 1: Location of Prayagraj city

administration limits. The overall municipal administration of the notified cantonments is the function of the cantonment boards and is hence excluded from the current study. The CB area is divided into 7 wards with a total population of 5157 persons (2011 Census).

For the purpose of the present study, we have taken into account Prayagraj City under the Prayagraj Municipal Corporation which is represented by 80 wards spread across the city and grouped into seven zones designated A to G (Fig. 2). A zonal profile of all the zones

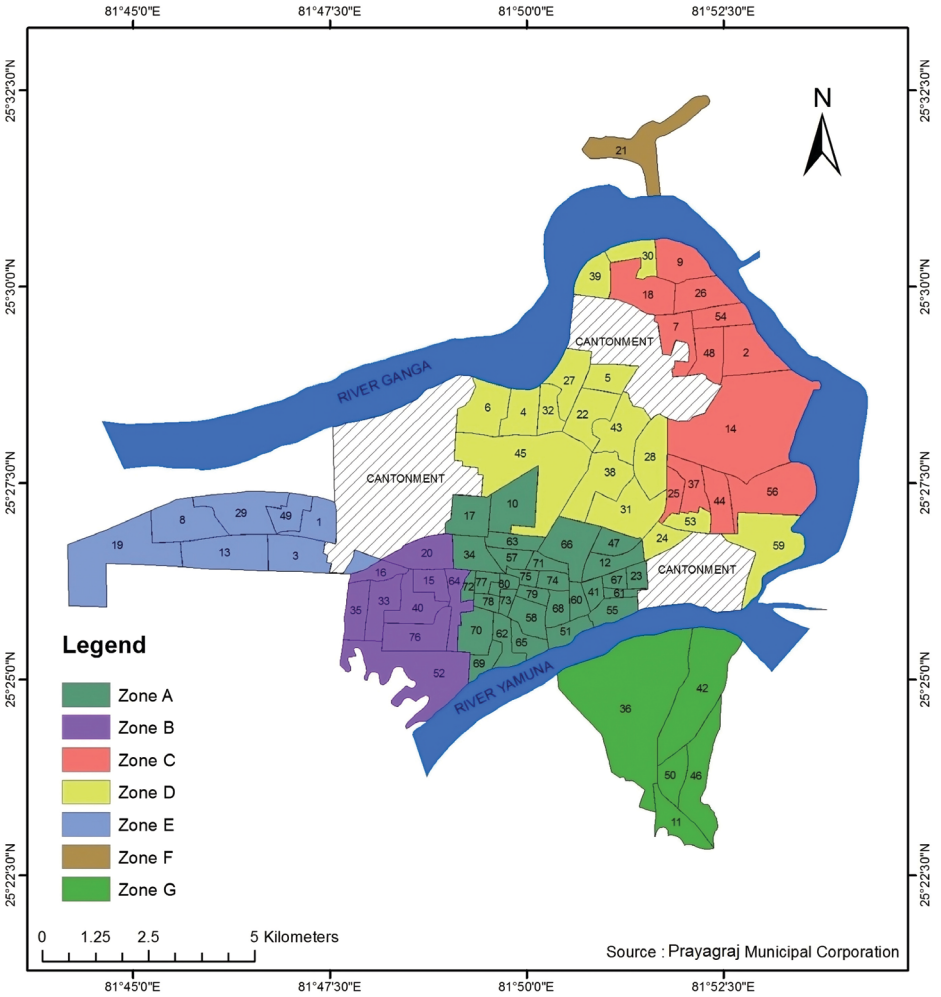

Fig. 2: Zonal and ward-wise division of Prayagraj city

and the number of wards included in them is given in Table 1.

Materials and methods

As mentioned previously, urban green spaces in Prayagraj are divided into two categories: parks and open spaces; and are collectively called public open spaces or POS. In order to understand the distribution, number, and extent of POS in the city, temporal LANDSAT satellite imageries and Google Earth images have been used for identification and demarcation. Google Earth imagery provides a high quality, open access, and high-resolution remote sensing platform for spatial studies especially in urban perspective having a highly dense and mixed land use. Consequently, the parks and open spaces of Prayagraj have been identified on the Google Earth platform and digitised into KML files.

Intensive field survey across the city has been carried out to locate and map these

Table 1: Zonal profile of Prayagraj city

Zone	No. of wards	Population	Area (km^2)
A	30	403043	12.52
B	09	466700	8.02
C	12	168484	15.27
D	16	242641	17.44
E	07	121006	9.22
F	01	21495	1.58
G	05	86676	11.54
Total	80	1210046	75.6

Source: Derived from Census of India and satellite data through GIS Techniques

parks and open spaces. The field survey data supplemented information regarding the location & extent, accessibility, and physical status of green vegetation in the particular unit. Analysis of remote sensing data has been supplemented by ground verification through GPS devices to obtain the current status of these features in the city. Later on, these KML features are imported into the ArcMap environment where KML file have been converted into Layer file using the ArcMap software which is then exported as Shapefile and layered over LANDSAT imagery to prepare a spatial inventory of the parks and opens spaces spatial data in Prayagraj city.

These parks and open spaces are classified into the seven zones of the city (Zones A-G). Finally, the areal extent and coverage of parks and open spaces in the city are calculated using geospatial techniques. The areal extent of parks and open spaces in Prayagraj City is then compared with other Indian and global cities.

Results

Parks and open spaces

Figures 3A and 3B pertain to Prayagraj City for the years 1985 and 2018 respectively which clearly reveal a significant reduction in the greenery within the city within a span of 33 years. The parks and open spaces have in large measure been replaced by roads, buildings, and houses. The decline can be seen especially in the centre of the city and along the major roads and railways.

Based on the 2018 image, the current distribution of parks and open spaces in the city has been identified (Fig. 4). There are a total of 204 identified parks and open spaces in the city out of which the 7 zones of the city have 181 and the remaining are located in the CB. As noted earlier, the parks and open spaces included within the city boundaries as defined by Prayagraj Municipal Corporation have been considered for the study. As can be easily seen (Fig. 4) the central and northeastern part of the city has the greatest number of parks and open spaces which decreases as one moves towards the periphery.

Zonal distribution of parks and open spaces

Together all 7 zones cover an area of 75.6 km^2 with a total population of 11,12,544 persons (Census, 2011 population, Table 1).

Fig. 3A: Google Earth Images of Prayagraj, 1985

Fig. 3B: Google Earth Images of Prayagraj, 2018

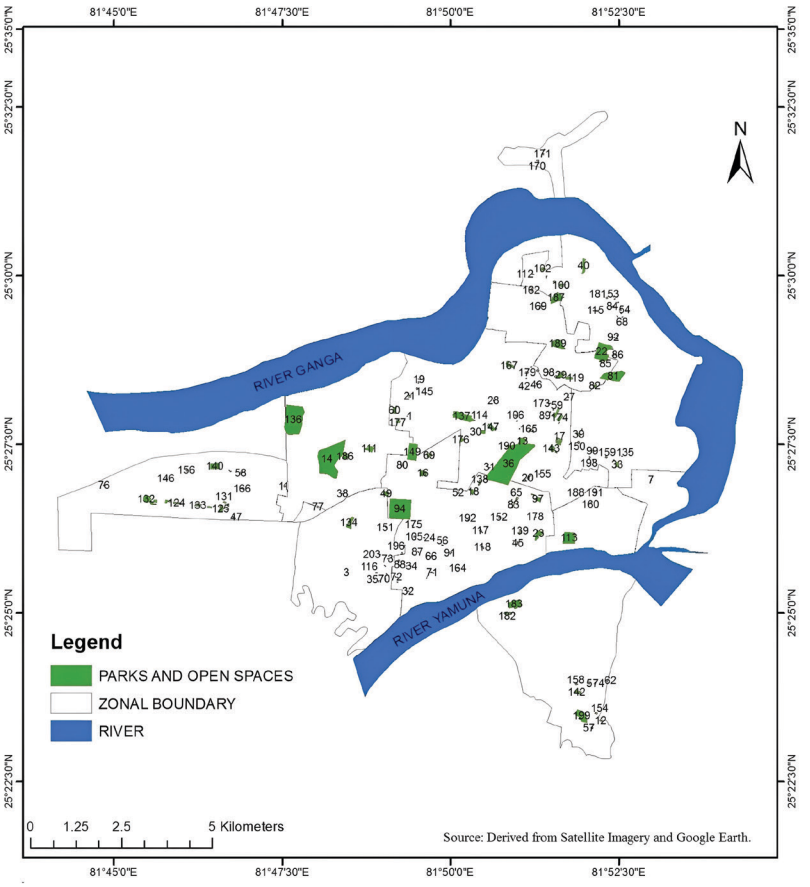

Fig. 4: Parks and Open Spaces in Prayagraj

Table 2: Zonal distribution of parks and open spaces in Prayagraj

Zones	No. of POS	Area (km^2)	% of POS to zone area
A	36	0.427625	3.80
B	15	0.05726	0.80
C	39	0.394149	2.87
D	52	1.010131	6.45
E	25	0.155887	1.88
F	03	0.006323	0.45
G	11	0.162795	1.57
Total	181	2.21417	3.26

Source: Derived from satellite imagery and Google Earth.

Table 3: Per capita availability of parks and green spaces in Prayagraj

Zones	Population	Area (m^2)	per capita availability (m^2/person)
A	403043	427625	1.06
B	466700	57260	0.12
C	168484	394149	2.34
D	242641	1010131	4.16
E	121006	155887	1.29
F	21495	6323	0.29
G	86676	162795	1.88
Total	1210046	2214170	1.83

Source: Derived from satellite imagery and Google Earth.

There are a total of 181 parks and open spaces identified in these zones covering an area of 2.214 km^2 out of a total of 75.6 km^2 of the city area constituting only 3.26 percent (Table 2). The table clearly shows that Zone D has the largest number of POS followed by Zone C and Zone A. The other Zones have far fewer POS, particularly in Zone F. However, these zones greatly vary in terms of their areal extent and population. For example, Zone D is located in the centre of the city and is also the largest zone in terms of its area and second largest in population. Due to the diversity in area and population of these zones, it was considered necessary to compare them on the basis of per capita availability of parks and open green spaces in different zones as well as with the city as a whole. Table 3 has these details.

The table shows that 1.83 m^2 of open space per person is available to the residents of the city as a whole. The largest area under parks and open spaces is found in Zone D and the lowest is found in Zone B.

Figure 5 shows that despite having a higher percentage of POS area, several zones have lesser per capita availability of POS due to the larger population in these zones which reduces the per capita availability in all the

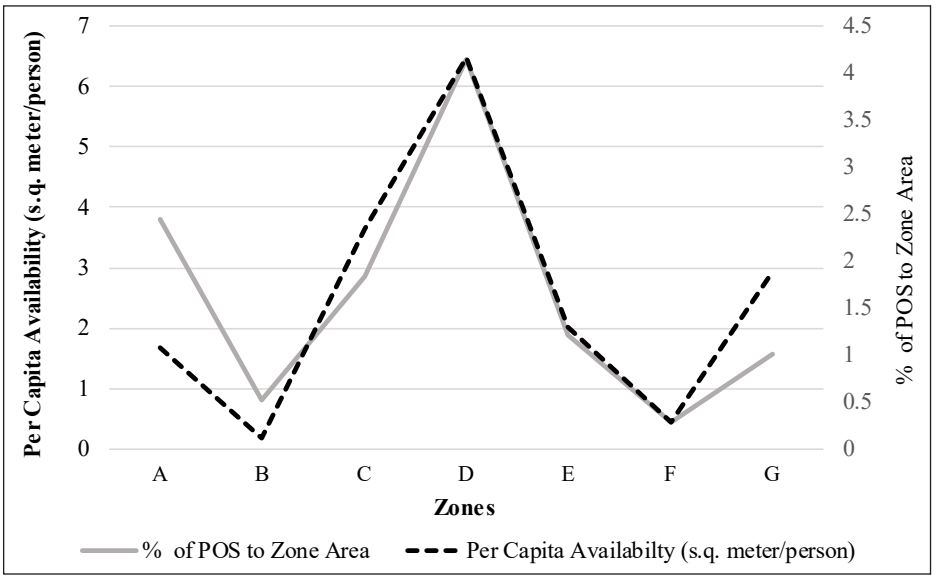

Fig. 5: Comparison of % of the area under POS to its per capita availability

zones except G which has a higher per capita availability of POS compared to POS area owing to its lesser population.

Zone A comprises the oldest part of the city as well as the Central Business District i.e. which is densely populated with narrow streets and lanes of tiny houses together with small informal businesses intertwined in a way almost inseparable and leaving little scope for open spaces or green parks, most of which have been encroached by slums and squatter settlements. Zone B is yet another region of tightly packed dwellings and narrow streets where most of the old population had settled with several architectural remains of the Mughal period scattered in between the crowded localities. The zone lacks provision for any public parks and green spaces except for a few which are owned by schools and colleges. Zone C is located in the eastern part of the city partly extending into the flood plain of river Ganga with uneven population distribution away from the flood zone. Most of the city's prominent educational institutions lie within this zone having big parks and open green spaces as well as several government housing schemes also provide for POS. Located in the heart of the city, Zone D is the most urbanized region among all the other zones where the large number of educational institutions and government buildings house a number of POS. Being one of the most expensive areas of the city, the cost of land makes it very difficult for densely packed small dwellings to develop. Hence most POS have survived in this zone. Being the center of the city administration POS has been encouraged by the city authority in this zone. Zone E is located on the western margin of the city along the North Central Railway line comprising mostly slum dwellings which are poor in terms of POS availability. Zone F is the smallest outcrop of the city flung across the river Ganga in the north. It has mostly

Table 4: List of cities by percentage of area under POS

City	% Area under POS	Year	Source
Amsterdam	13.00	2018	Statistics Netherlands/TNO
Austin	10.00	2019	Austin Parks Foundation
Barcelona	28.00	2019	Urban Ecology Department / Barcelona City Council
Bogotá	4.90	2017	Departamento Administrativo de la Defensoría del Espacio Público
Brussels	18.80	2015	IBGE
Buenos Aires	9.40	2018	Estadísticas y Censos
Cape Town	24.00	2016	City of Cape Town
Chengdu	42.30	2017	Statistics Bureau of Chengdu
Dublin	26.00	2018	Dublin City Council
Edinburgh	49.20	2016	ESRI
Guangzhou	19.78	2018	Guangzhou Statistical Yearbook 2019
Helsinki	40.00	2018	City of Helsinki
Hong Kong	40.00	2020	Agriculture, Fisheries and Conservation Department; Survey & Mapping Office, Lands Department
Istanbul	2.20	2015	Istanbul Metropolitan Municipality
Johannesburg	24.00	2002	State of the Environment Report, City of Johannesburg 2009
Lisbon	18.00	2021	CML-DM do Ambiente - Estrutura Verde - Clima e Energia
London	33.00	2022	Greenspace Information for Greater London CIC 2022
Los Angeles	34.70	2016	LA County Parks and Recreation Needs Assessment
Melbourne	9.30	2017	Victorian Planning Authority
Milan	13.74	2020	Direzione Verde Comune Milano
Montréal	12.82	2021	Ville de Montréal, Direction des grands parcs et du verdissement
Moscow	18.00	2017	Department of Natural Resources
Nanjing	40.67	2018	Nanjing Statistics Bureau
New York	27.00	2010	New York City Department of City Planning Land Use
Oslo	68.00	2019	Bymiljøetaten, Oslo kommune
Paris	10.00	2019	Institut Paris Region
Rome	38.90	2017	Roma Capitale
San Francisco	13.00	2017	San Francisco Department of Recreations and Parks 2017 Community Report
Seoul	27.91	2019	Seoul Metropolitan Government
Shanghai	16.20	2017	Shanghai Municipal People's Government
Shenzhen	40.90	2016	Shenzhen Statistical Yearbook
Singapore	47.00	2011	National Parks Board
Stockholm	40.00	2017	Statistics about Stockholm - Sweco
Sydney	46.00	2010	New South Wales Department of Planning
Taipei	6.56	2021	Parks and Street Lights Office, Taipei City
Tokyo	7.50	2015	Bureau of Urban Development
Toronto	13.00	2018	City of Toronto
Vienna	50.00		Stadt Wien
Warsaw	17.00	2015	Head Office of Geodesy and Cartography
Zürich	41.00	2018	Grün Stadt Zürich

Source: World Cities Culture Forum

suburban settlements and mostly farmlands with less urbanization as compared to other parts of the city core. Zone G is again located outside the core of the city and has a lesser rate of urbanization therefore a higher percentage of POS to zone area is available.

International comparison

The network of open public spaces not only improves the quality of life but also the mobility and functioning of the city. As cities and urban areas all over the world continue to grow at unprecedented rates (often diversifying beyond the formal operational sphere), there is a need to continuously support local and national governments in developing legislation, policy, norms, and practices, which support them to adopt a holistic and integrated approach to the planning, design, development, creation, protection, and management of public spaces. There are two ways to measure Park and Open Spaces in a city. Firstly, we can find out the percentage of area covered by POS in a city and secondly, by the per capita availability of POS in the entire city. In the preceding paragraphs, we have shown the amount of POS measured in Prayagraj by both methods. In this section, we will compare the amount of POS in Prayagraj to the global average and global standards for a better understanding of the level of POS in the city.

In terms of the percentage of city area under POS, the UN-Habitat (2018) advocates a minimum of 20 percent of the city area as POS. World Cities Culture Forum (n.d.) has created a database of 40 cities and lists the percentage of area under POS in each of them. A cursory reading of Table 4 reveals the inadequacy of POS in Prayagraj when compared with many other cities of the world. Availability of POS in Prayagraj is only marginally better than just one of the world included in the table, i.e. Istanbul in Turkey. Moreover, Prayagraj compares poorly with cities from developing countries too.

When compared with some cities in India, the situation of Prayagraj is no better, comparable only with Mumbai (2.5% POS; Babar, 2012), which is one of the most congested cities in the world. The National Capital Territory of Delhi has 20 percent of its area as POS and Chandigarh, the north Indian city has 35 percent of its area under POS (Babar, 2012). Prayagraj is way below the minimum threshold of POS recommended by the United Nations.

In terms of per capita availability of POS in cities, studies have shown that cities should have a minimum of 9 m^2 per person area under POS (Maryanti *et al.*, 2017; Senik and Uzun, 2022) a benchmark supported by the World Bank too. This is of course the minimum and many advocate a much higher per capita POS. World Health Organisation (Jafrin and Beza, 2018; Shahfahad, 2019) for example, recommends 50 m^2 per capita (Russo and Cirella, 2018). In their study of POS in 8 cities of the world, Maryanti *et al* (2017) found per capita availability of POS are as high as 48.5 m^2 in Los Angeles followed by Cambridge (46 m^2) Greater London (40 m^2), Washington (38 m^2), Kansas City (36.4 m^2), Edinburgh (29 m^2), Minneapolis (20 m^2) and Bristol (10 m^2). In contrast, Prayagraj has only 1.83 m^2 per capita availability of POS which is way below the minimum (9 m^2) and the preferred (50 m^2) open spaces to be qualified as a smart city by international standards.

Even by national standards, Prayagraj city compares poorly with some of the major Indian cities. For example, Delhi has a per capita availability of POS of 5.5 m^2, Mumbai 2.01 m^2, Hyderabad 0.5 m^2,

Gandhinagar 147.6 m^2, and Chandigarh 54.45 m^2 (Govindarajulu, 2014)

It is clear from this that only Hyderabad and Chennai, two mega cities of South India have less per capita POS availability than Prayagraj. Cities comparable to Prayagraj in terms of population and area like Jaipur and Chandigarh have much greater percent of POS as well as per capita availability of POS.

Summary and conclusion

One of the aims of the smart city mission is to provide a sustainable environment and green spaces in Indian cities by preserving and developing open spaces in order to enhance the quality of life of the citizens, and by reducing the urban heat effects to promote eco-balance (Smart City Mission, n.d.). Prayagraj being one of the original 100 cities selected for smart city missions largely fails in this goal going by this single criterion. The current availability of POS compares poorly with similar cities in developing countries and very poorly with respect to cities in developed countries. The city does not even provide the minimum amount of POS in terms of percentage area and per capita POS availability. Thus, at the current level, Prayagraj is unable to fulfill the objective of the smart city mission of providing adequate POS to its citizens and this is a major challenge that the smart city mission must address before it can transform Prayagraj into a smart city.

Competing interest

The authors declare that they have no conflict of interest.

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Roohi Rawat
Assistant Professor,
Department of Geography,
Banaras Hindu University,
Varanasi, Uttar Pradesh

Avijit Sahay*
Assistant Professor,
Department of Geography,
Doon University,
Dehra Dun, Uttarakhand

Amrita Bajaj
Associate Professor,
Department of Geography,
Shaheed Bhagat Singh College,
Delhi University, Delhi

*Author for correspondence
E-mail: avijit@doonuniversity.ac.in