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IMPACT OF POPULATION GROWTH ON OPEN SPACE IN INDORE CITY

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Abstract: The quality of life in urban areas depends on open and green spaces that are specifically designed in urban land-use green belt zones. Open and green spaces are important aspects of urban land use planning. They have socio-economic and ecological importance in terms of preserving agricultural land, serving as a natural sink for pollution, supplying commercial forestry products like horticulture and floriculture for the low-income urban community, and providing a place for recreational activities. Therefore, urban planners always recommend a minimum quantity of open space in relation to the population density. They also provide suggestions regarding the spatial arrangement of open space within the city in relation to city land use planning. This study aims to analyze the per capita availability of open spaces in all wards of Indore city and propose measures to improve greenery in wards where it falls below prescribed standards. The study will be conducted by collecting the required data from Indore Municipal Corporation and from satellite. Ward-wise digitization of available nine types of open space (water bodies, dry beds of water bodies, parks, playgrounds/maidans/vacant land, crematorium/burial grounds, cultivated lands, orchards/city forests, nurseries, rocky outcrop/barren land) in the city will be carried out with the help of GIS Software (Google Earth Pro and ArcGIS). This will determine the ward-wise availability of open spaces. Subsequently, the per capita required availability of open space in relation to population density will be calculated in accordance with the norms of "Urban and Regional Development Plans, Formulation and Implementation" (URDPFI), and wards with shortfall and adequacies in per capita open space availability will be identified.

Keywords: Quality of Life, Open and Green Spaces, Urban Land-use

Introduction: In the metropolitan cities of India, due to increasing urbanization and unplanned development, the problems of land use space and pollution are gradually increasing. The rapid expansion of urban areas due to rise in population and economic growth exerts additional demand on natural resources, thereby causing land use changes, especially in mega cities. As a result, problems related to the use of urban land for additional infrastructure and settlements have been emerging **(Bloom, D.E., et al., 2007)**. The unplanned, unsystematic, and rapid urbanization causes harmful impacts on various environmental components **(Uttara, S., et al., 2012)**. Due to this, the percentage of mandatory open and green spaces in the cities cannot be observed. The condition worsens in the city's central business districts (CBDs) and commercial areas, with a gradual decrease in the remaining open spaces and increasingly polluted surrounding environment. This directly affects the urban environment and the quality of life of urban people. The quality of life in urban areas depends upon the availability of these open and green spaces, which are specially designated in the urban land-use green belt zones. Agricultural areas as well as parks and other types of vacant land have important functions for the resident population **(Shi, W., 2014)**. The green areas serve as absorbers of pollution. The green belt is also seen as an aesthetic component of the natural environment that is interspersed with the built-up areas of the city. Open spaces serve many functions beyond aesthetics; they are sites for augmenting groundwater recharge and pollution

abatement **(Ramaiah, M. & Avtar, R., 2019)**. They function as recreational spots in the form of parks and playgrounds, attracting people from all segments of the population. Open and green spaces are important aspects of urban landuse planning. They hold socio-economic and ecological importance, preserving agricultural land, acting as natural sinks for pollution, supplying commercial forestry resources like horticulture and floriculture for low-income urban communities, and providing places for recreational activities **(Urban Greening Guidelines, 2014)**. Therefore, urban planners always recommend a minimum quantity of open spaces in relation to the population density and the city's location. They also provide suggestions regarding the spatial arrangement of open spaces within the city in accordance with the city's land-use planning. Open spaces can be broadly analyzed under two categories: those that are interspersed within the built-up areas of the city and those that encircle the built-up area. In this study, the former type of open space is categorized into nine types: **parks, playground/maidan/vacant land, crematorium/burial ground, nurseries, orchards/city forest, agriculture land, water bodies, dry beds of water bodies, and rocky outcrop/barren land.**

Study Area: Indore stands as one of the most renowned urban centers within the Indore District of Madhya Pradesh. It is well known for trade, commerce, education, and hospitality. It is also recognized as the commercial capital and educational center of the state. As per Section 4 of the Madhya Pradesh Town and Country Investment Act, 1973, it is the largest city in the "Agricultural Industrial Area." It is situated at 22°43' north latitude and 76°43' east longitude on the Malwa Plateau. The city is located at an altitude of 548.64 meters above sea level. It follows a mayor-council form of government. The city is encompassed by the Indore Municipal Corporation, spanning an area of 279 km^2. This territory is divided into 19 distinct zones, each of which contains 85 wards.

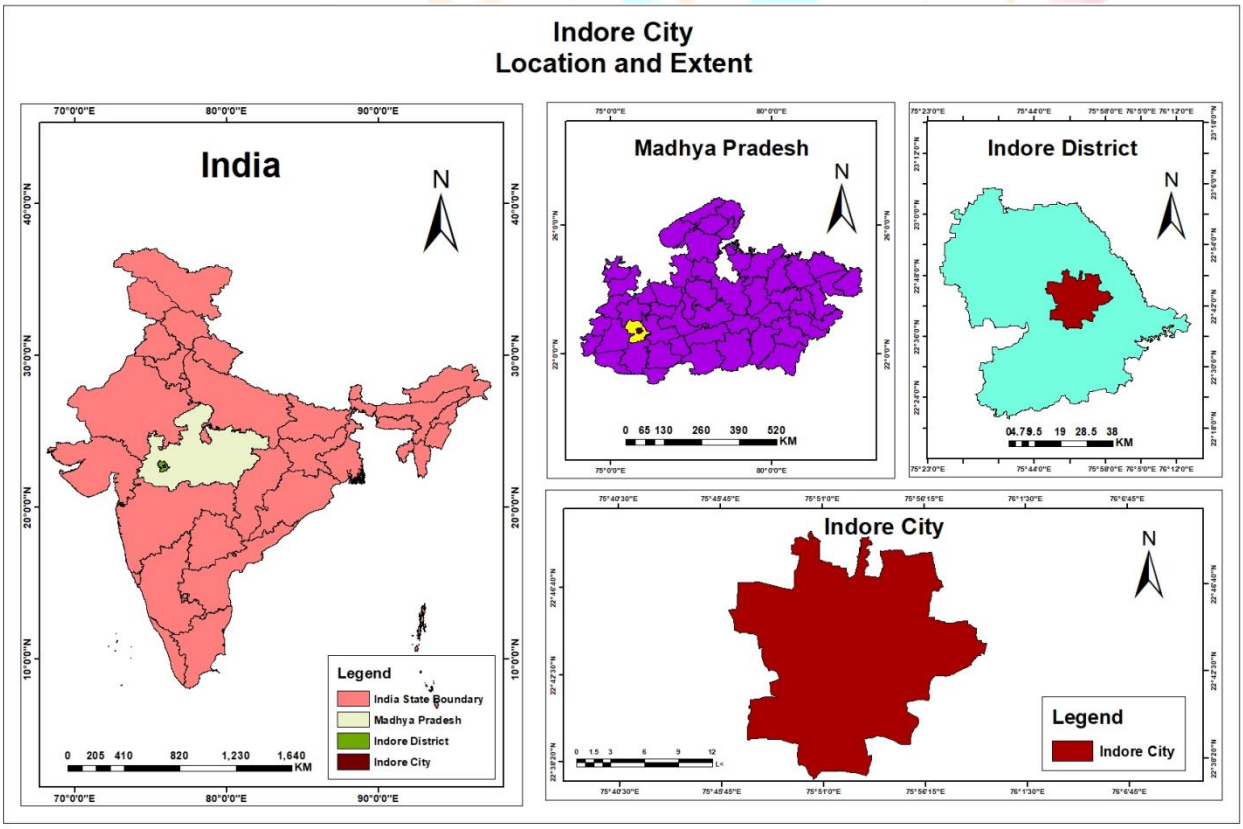

Figure 1: Indore City Location and Extent

Objectives of the Study: The study aims to achieve the following objectives:

1. To study the distribution of open spaces in all wards of Indore metro city.
2. To evaluate their adequacy with respect to the population.
3. To formulate future plans to increase the greenery in the city.

Research Methodology: The study aims to understand the impact of urbanization on the urban environment due to changes in land use. The study focuses on the availability of open space in different wards of the city. The study is based on the secondary source of data. The ward wise population data was collected from the Indore Municipal Corporation and the ward map was collected from Indore Smart City Office. Satellite data was

collected to determine the area of available open spaces in different wards of the city. The area of various types of open space in all **85 wards** of the city was calculated using GIS software, including **'Google Earth Pro'**, **'Global Mapper'**, and **'ArcGIS'**. In Google Earth Pro, all nine types of open spaces were digitized into vector polygonal files. After completing the polygons for all available open spaces, the vector files in 'Google Earth pro' were converted and stored as shapefiles (.shp) with the help of Global Mapper. These shapefiles were then processed in ArcGIS to obtain the area of all the polygons. Subsequently, the obtained data was converted into maps. This process achieved an accuracy rate of more than 95%.

Results and Discussions

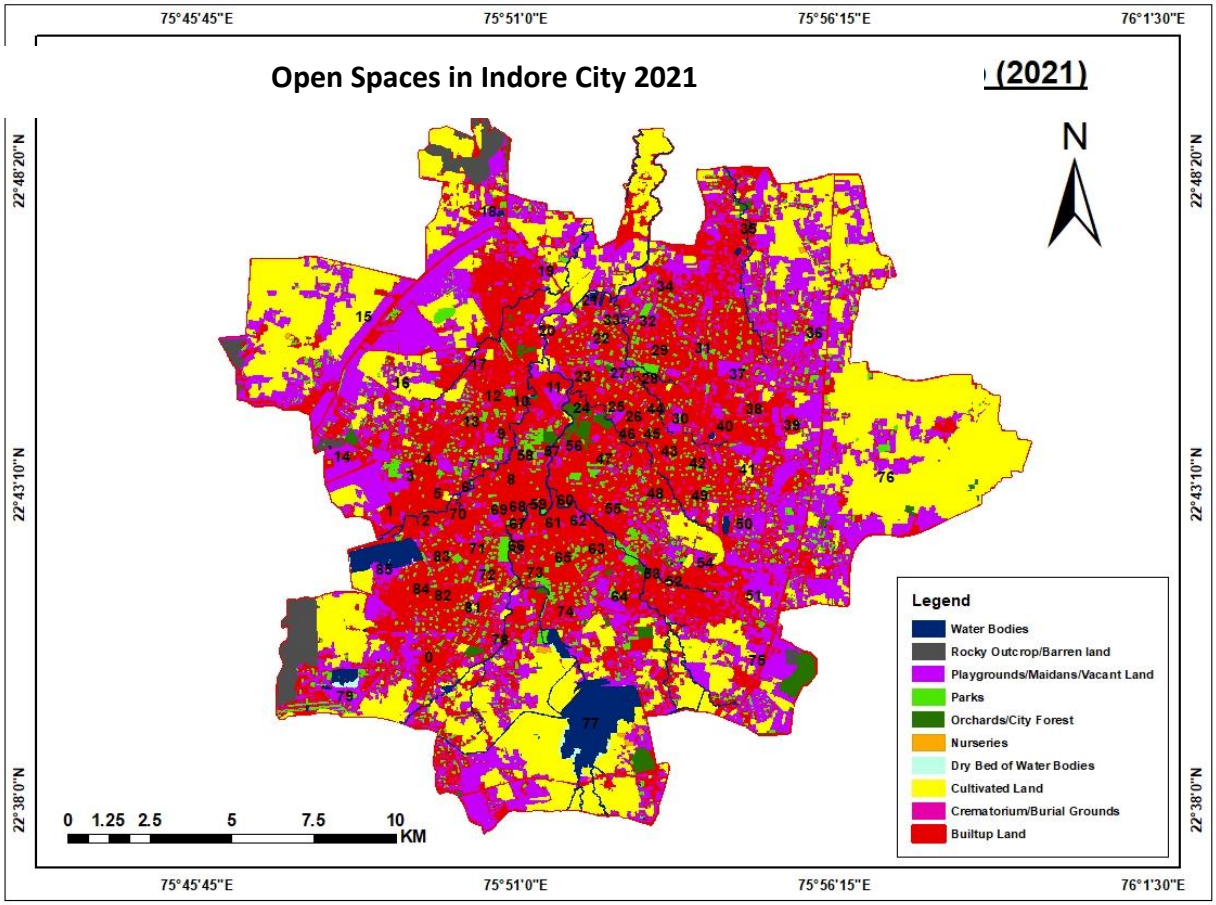

Figure 2: Open spaces in Indore City 2021

Ward-Wise Description of Open Spaces: The distribution of open space within the different wards of the city varies significantly. To describe this diversity, Indore metro city is categorized into five distinct categories based on the ratio of the smallest to the largest open space availability, as presented in the table and map below:

Table 1: Ward-Wise Available Open Space in Indore City

Category (Amount of Open Space)	Class (m^2)	Total Wards	Description of Wards (Ward No.)
Negligible	2,248-5,542	4	2,8,26,84
Very Low	13159-99,261	13	68,61,46,5,60,45,59,67,44, 53,12,62,10

Low	1,00,464-9,20,959	44	43,4,82,13,52,69,65,6,25,70, 22,48,73,58,28,23,40,71,72, 42,49,63,38,9,83,29,24,30, 66,33,17,47,27,7,81,32,56, 41,3,11,80,31,57,20
Medium	10,82,073-82,39,240	18	55,34,21,51,64,37,50,1,14,78, 54,74,85,39,19,16,18,75,
High	1,03,21,926-27,01,906	6	35,36,79,77,15,76

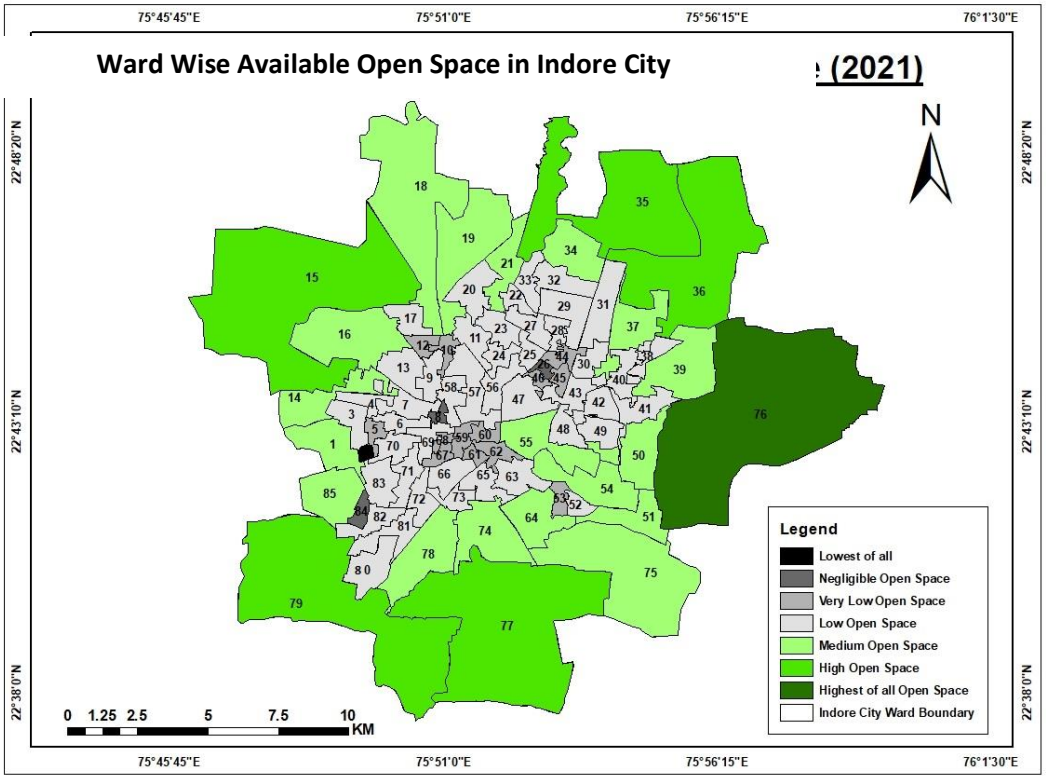

Figure 3: Table 1

1. **Negligible Amount of Open Space:** There are four wards in the city that possess an almost negligible amount of open space. The ward with the least open space is **'Chandan Nagar'**, comprising a mere **2,248 m^2** area and located in the western part of the city. This availability is seen due to the Saraswati River along its northern boundary. The ward exhibits compact type of residential structure, characterized by narrow streets and surrounded by built-up structures without any parks or open spaces.

Following closely, the **'Juna Risala'** ward **(3,675 m^2)** is situated in the center part of the city. It has two parks, one in the west (525 m^2) and another in the south (1,048 m^2), as well as a school playground (2,110 m^2).

Similarly, the **'Jeen Mata'** ward (4,418 m^2), also located in the center part of the city, contains two parks. One park lies in the north-west (1,287 m^2), while the other is situated in the south-east (313 m^2).

Lastly, the **'Dwarkapuri'** ward (5,542 m^2) in the western part of the city has a park (2,305 m^2) and a playground (3,237 m^2). This ward's open space is characterized by its park and playground facilities. All these wards have a compact residential pattern.

2. **Very Low Amount of Open Space:** The second category represents wards with a very low availability of open space, ranging from 13,159 m^2 to 99,261 m^2 . The wards falling in this category are Bambai Bajar (13,159 m^2), Tatya Sarwate (19,766 m^2), Somnath (28,153 m^2), Rajnagar (50,285 m^2), Ranipura (53,712 m^2), Bhim Rao Ambedkar (54,101 m^2), Harsiddhi (60,531 m^2), Maharaja Holkar (64,879 m^2), H.I.G. (68,212 m^2), Dr. Maulana Azad (71,314 m^2), Govind Colony (73,006 m^2), Ravji Bajar (86,230 m^2), and Banganga (99,261 m^2).

   These wards are primarily located in the center part of the city and feature a commercial-cum-residential land-use pattern. Many of them possess a mix of various types of open spaces, including parks, playgrounds/maidans, water bodies, and crematorium/burial grounds. However, the 'Harsiddhi' ward, for instance, only contains two types of open spaces, namely parks and water bodies.

   Due to their location in the central business district (CBD) and its immediate surroundings, these wards suffer from a scarcity of open space, a result of the early stages of the city's development. The process of urbanization has led to the diminishing of open spaces within these wards.

3. **Low Availability of Open Space:** The third category covers wards with a low availability of open space, ranging from 1,00464 m^2 / 0.1 km^2 to 9,20,959 m^2 / 0.9 km^2 . The wards in this category are Shrinagar (1,00,464 m^2 / 0.1 km^2), Sukhdev Nagar (1,11,136 m^2 / 0.11 km^2), Sudama Nagar (1,32,227 m^2 / 0.13 km^2), Sangam Nagar (1,39359 m^2 / 0.13 km^2), Musakhedi (1,41,832 m^2 / 0.14 km^2), Jawahar Marg (1,46,105 m^2 / 0.14 km^2), Sant Kanwarram (1,47,441 m^2 / 0.14 km^2), Malharganj (1,47,441 m^2 / 0.14 km^2), Nanda Nagar (1,55,292 m^2 / 0.15 km^2), Loknayak Nagar (1,57,850 m^2 / 0.15 km^2), Pandit Dindayal Upadhyay (1,66,869 m^2 / 0.16 km^2), Gita Bhawan (1,72,177 m^2 / 0.17 km^2), Laxman Singh Chauhan (1,85,306 m^2 / 0.18 km^2), Imli Bajar (2,22,386 m^2 / 0.22 km^2), Ma Tuleja Bhawani (2,24,255 m^2 / 0.22 km^2), Swargiya Rajesh Joshi (2,41,571 m^2 / 0.24 km^2), Khajrana Ganesh (2,48,710 m^2 / 0.24 km^2), Dravid Nagar (2,48,978 m^2 / 0.24 km^2), Lokmanya Nagar (2,57,534 m^2 / 0.25 km^2), Swami Vivekanand (2,58,899 m^2 / 0.25 km^2), Vrindavan (2,81,405 m^2 / 0.28 km^2), Gumashta Nagar (2,81,619 m^2 / 0.29 km^2), Dr. S.P. Mukharji (2,90,414 m^2 / 0.29 km^2), Sant Balaji Nath Maharaj (2,95,446 m^2 / 0.29 km^2), Sant Ravidas (3,16,643 m^2 / 0.31 km^2), Shahid Hemu Colony (3,31,133 m^2 / 0.33 km^2), Sukhliya (3,54,736 m^2 / 0.35 km^2), Kushwah Nagar (3,71,899 m^2 / 0.37 km^2), Sardar Vallabh Bhai Patel (4,18,249 m^2 / 0.41 km^2), Pashupati Nath (4,34,734 m^2 / 0.43 km^2), Janta Colony (4,91,739 m^2 / 0.49 km^2), Annapurna (5,27,691 m^2 / 0.52 km^2), Atal Bihari Vajpeyi (5,41,230 m^2 / 0.54 km^2), Snehalata Ganj (5,57,629 m^2 / 0.55 km^2), Kailashpuri (5,98,184 m^2 / 0.59 km^2), Kalani Nagar (6,47,312 m^2 / 0.64 km^2), Bhagirathpura (6,59,883 m^2 / 0.65 km^2), Dr. Rajendra Prasad (7,14,207 m^2 / 0.71 km^2), Maharaja Chatrasal (7,55,069 m^2 / 0.75 km^2), Devi Ahilya Bai (8,18,662 m^2 / 0.88 km^2), and Govind Nagar (9,20,959 m^2 / 0.92 km^2).

   Among these wards, Sukhdev Nagar, Sudama Nagar, Sant Kanwarram, Dravid Nagar, Kalani Nagar, Dr. Rajendra Prasad, and Maharaja Chatrasal only contain two types of open spaces, namely parks and playgrounds/maidans/vacant lands. On the other hand, the remaining wards feature a mix of four to five types of open spaces, including parks, playgrounds, water bodies, agriculture lands, and crematorium/burial grounds.

   These wards are distributed from the center to middle parts of the city, primarily spanning from the northeast to the southwest. They include notable locations such as Vijay Nagar, Chappan, Ganesh Mandir, Laal Bagh Palace, Dusshera Maidan, Pardesipura, and the Railway Station. These places are renowned crowd hotspots in the city, holding commercial and cultural significance. The surrounding areas of these locations are predominantly residential due to their high importance.

4. **Medium Availability of Open Space:** The fourth category includes wards with a medium availability of open space, ranging from 10,82,073 m^2 / 1.08 km^2 to 82,39,240 m^2 / 8.2 km^2 . The following wards are falling in this category, Sauth Tukoganj (10,82,073 m^2 / 1.08 km^2), Shahid Bhagat Singh (11,36,843 m^2 / 1.1 km^2), Shyam Nagar (11,98,267 m^2 / 1.1 km^2), Bhagvati Nagar (12,34,957 m^2 / 1.2 km^2), Chitavad (14,15,412 m^2 / 1.4 km^2), Sai Krupa (14,88,931 m^2 / 1.4 km^2), Brajeshwari (15,50,389 m^2 / 1.5 km^2), Sirpur (15,71,989 m^2 / 1.5 km^2), Ashok Nagar (16,66,646 m^2 / 1.6 km^2), Choithram (17,55,440 m^2 / 1.7 km^2), Residency (18,16,063 m^2 / 1.8 km^2), Vishnupuri (19,47,969 m^2 / 1.9 km^2), Prajapat Nagar (29,27,182 m^2 / 2.9 km^2), Nahar Shahvali (30,28,560 m^2 / 3 km^2), Vishwakarma (37,86,704 m^2 / 3.7 km^2), Nandbagh (4,18,078 m^2 / 4.1 km^2), Sant Kabir (51,24,136 m^2 / 5.1 km^2), and Palda (82,39,240 m^2 / 8.2 km^2).

   Within this category, five to six types of open spaces can be observed, including parks, playgrounds/maidans/vacant lands, agriculture lands, water bodies, nurseries, and orchards/city forests. No ward within this category has fewer than four types of open spaces. These wards are primarily situated in

the middle-outer and outer parts of the city. The predominant land use pattern in these wards is residentialcum-commercial.

Wards that share boundaries with outer wards have a significant contribution to the open space availability. Notable examples include Palda, Sant Kabir, Vishwakarma, and Nandbag.

5. **High Availability of Open Space:** The fifth category covers wards with a high availability of open space, ranging from 10,32,196 m^2 to 27,01,906 m^2 (1.03 km^2 to 2.70 km^2). There are only six wards in this category, these are Lasudiya Mori (10,32,196 m^2 / 1 km^2), Nipaniya (11,29,329 m^2 / 1.1 km^2), Sukh Niwas (15,64,406 m^2 / 1.5 km^2), Bilawali (21,70,114 m^2 / 2.1 km^2), Bijasan (21,78,790 m^2 / 2.1km^2), and Mundala Nayata (27,01,906 m^2 / 2.7km^2).

   Within these wards, six to seven types of open spaces can be found. Notably, Bilawali, Bijasan, and Mundala Nayata have seven categories of open space. The presence of agriculture lands and vacant lands contributes significantly to the high availability of open space in these wards. The abundance of vacant lands is often a result of encroachment on agricultural lands, which are gradually transforming into vacant colonies for future urban development.

   The land use of these wards can be described as rural-cum-urban, as they were surrounding villages of the city before their incorporation into the city's municipal corporation area in 2014. Consequently, many of the residents in these wards are farmers who cultivate the agricultural lands within these areas.

Adequacy of Open Space According to Population Size: To ensure an adequate amount of open space within cities and safeguard existing open spaces from the negative effects of population growth, preservation and maintenance of these spaces are crucial. The World Health Organization recommends a minimum of **9 m^2** per capita of urban green or open space, which should be accessible, functional, and safe. In India, the "Urban and Regional Development Plans Formulations and Implementations" (URDPFI) suggests a minimum of **12m^2 /capita open space.**

In this study, the aforementioned standard of 12m^2 /capita is used to calculate the per-capita availability of open space in Indore metro city.

Ward-Wise Per Capita Open Space: Based on the standard of 12m^2 /person for open space, the availability of open space in the city can be categorized into six distinct groups. The data calculated for the 85 wards of city for the year 2021, exhibits substantial variability, ranging from 0.05 m^2 /person to 777m^2/person (from center to outward). The table provided below illustrates the per-capita availability of open space across these 85 wards of the city.

Table 2: Ward-Wise Per Capita Open Space in Indore City (2021)

S. No.	Category	Class (per capita open space) in **m^2**	Total Wards	Description of Wards (Ward No.)
1	Negligible	0.05-1.24	8	2,8,26,84,68, 61,46,5
2	Very Low	1.60-5.98	21	60,45,53,59,44,12,67,10, 62,4,82,43,13,6,69,65,52, 70,25,22,48
3	Low	6.43-12.64	21	58,28,73,83,38,23,71,9,49 , 24,40,72,42,63,29,30,17, 66,33,47,27
4	Medium	13.05-23.71	11	81,7,56,3,41,80,32,11,57, 2 0,31
5	High	33.66-73.61	14	51,64,55,34,21,50,1,14,78 , 37,54,74,85,39
6	Very High	101.56-777.35	10	19,16,18,75,36,35,79,77,1 5,76

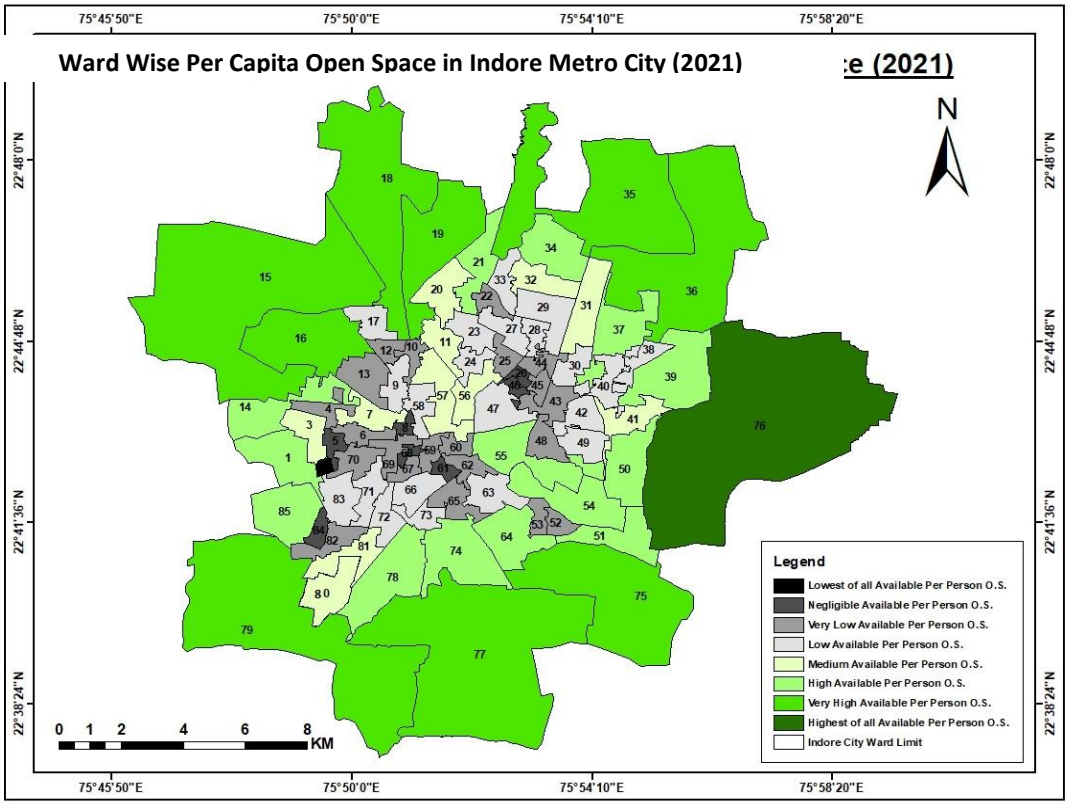

Figure: Table 2

The descriptions for these categories are provided below:

1. **Negligible Availability of Per Person Open Space:** This category comprises eight wards that have nearly lost their open space. Here, per capita availability of open space is ranging between 0.05 m^2 to 1.2 m^2 which is 10 fold away from the required open space 12 m^2 . The ward with the lowest per person open space availability is 'Chandan Nagar', offering only 0.05m^2 /person of open space. This availability practically equals to 'no open space' at all. The total population in this ward is 41,107. Other wards falling within this category include Juna Risala (0.09 m^2), Jeen Mata (0.14 m^2), Dwarkapuri (0.14 m^2), Bambai Bajar (0.42 m^2), Tatya Sarwate (0.64 m^2), Somnath (0.89 m^2), and Rajnagar (1.24 m^2).

   These wards are situated in the center and middle areas of the city. The predominant land-utilization pattern in these wards is commercial-cum-residential. These wards exhibit highly compact built-up structures, resulting in both horizontal and vertical congestion. Due to these conditions, there is high pollution and suffocating environment in these wards for the residents. Access to fresh air has become a dream for the inhabitants of these wards.

   The situation in these wards is alarming. Urgent and stringent regulations and plans are necessary to increase green spaces by hook or crook. Each and every possible space should be converted into green space (along with streets, roads, footpaths, every floor of buildings, roof top garden on every building, balcony of every house, etc.) to increase the greenery in these wards. With minimum space for horizontal gardens, the focus should shift toward implementing vertical gardens and establishing green corridors in these areas. Immediate action is required to deal with this critical issue in these wards.
2. **Very Low Availability of Per Person Open Space:** This category includes 21 wards with per capita open space ranging from 1.60 m^2 to 5.9 m^2 , which is far below the prescribed standards (12 m^2). The wards falling within this category are Ranipura (1.6 m^2), Bhimrao Ambedkar (1.66 m^2), Dr. Maulana Azad (1.7 m^2), Harsiddhi (1.9 m^2), H.I.G. (2 m^2), Govind Colony (2.04 m^2), Maharaja Holkar (2.07 m^2), Banganga (2.51 m^2), Ravji Bajar (2.73 m^2), Sukhdev Nagar (3 m^2), Sudama Nagar (3.2 m^2), Shri Nagar (3.24 m^2), Sangam Nagar (3.5 m^2), Malharganj (3.9 m^2), Jawahar Marg (4 m^2), Sant Kanwarram (4.16m^2), Musakhedi (4.35 m^2), Loknayak Nagar (4.63 m^2), Nanda Nagar (4.79 m^2), P. Dindayal Upadhyay (5.5 m^2), and Gita Bhawan (5.9 m^2).

   Most of these wards are situated in the Central Business District (C.B.D.) and its surrounding areas, while some are located in the middle parts of the city. Prominent places in the city, such as

L.I.G., Shri Nagar, Old Palasia, Krishi Upaj Mandi, and Sarwate Bus Stand, are situated in this category. These areas are predominantly commercial. The land-utilization pattern in most of these wards is a mix of commercial and residential.

The per capita availability of open space in these wards is notably low, raising concerns about the diminishing open/green spaces. As urbanization continues to exert pressure, the available open spaces are at risk of being absorbed. The present situation requires immediate attention and efforts towards preserving the existing vital open spaces and increasing green cover at any cost.

3. **Low Availability of Per Person Open Space:** This category comprises wards with per person availability ranging from 6.4 m^2 to 12.6 m^2 . A total of 21 wards fall within this range, including Imli Bajar (6.4 m^2), Ma Tuleja Bhawani (6.5 m^2), Laxman Singh Chauhan (6.7 m^2), Gumashta Nagar (6.8 m^2), Haji Colony (6.84 m^2), Swargiya Rajesh Joshi (7.1 m^2), Dravid Nagar (7.5 m^2), Vrindavan (7.7 m^2), Tilak Nagar (7.73 m^2), Sant Balajinath Maharaj (7.82 m^2), Khajrana Ganesh (8.06 m^2), Lokmanya Nagar (8.12 m^2), Swami Vivekanand (8.29 m^2), Navlakha (8.64 m^2), Dr. S.P. Mukharji (8.7 m^2), Sant Ravidas (8.75 m^2), Kushwah Nagar (9 m^2), Shahid Hemu Colony (9.17 m^2), Sukhliya (11.24 m^2), Sardar Vallabh Bhai Patel (11.34 m^2), and Pashupati Nath (12.6 m^2).

   These wards are situated in the center and middle parts of the city. Prominent locations such as Laal Bagh Palace, Dusshera Maidan, Holkar Stadium, Nehru Park, Malhar Ashram, I.T.I. Ground, Vijay Nagar, Scheme No. 54, Meghdoot Garden, Apollo Hospital, and Footi Kothi are situated in this category. These areas are well-developed parts of the city, witnessing both residential and commercial growth, which has led to a high population density and limited open space availability.

   Efforts should be directed towards increasing the per person availability of open space in these wards. Horizontal spaces such as playgrounds, parks, maidans, any other open spaces should be preserved, while vacant lands should be utilized for creating parks/playgrounds. Along with this, a sustainable increase can be achieved by increasing vertical greenery and by implementing innovative space utilization strategies.

4. **Medium Availability of Open Space:** This category encompasses 11 wards with per person open space availability ranging from 13 m^2 to 23.7 m^2 . The wards falling within this range are Annapurna (13.05 m^2), Janta Colony (13.31 m^2), Snehalata Ganj (13.7 m^2), Kalani Nagar (16.02 m^2), Kailashpuri (17.04 m^2), Dr. Rajendra Prasad (17.37 m^2), Atal Bihari Vajpeyi (17.67 m^2), Bhagirathpura (18.5 m^2), Devi Ahilya Bai (21.12 m^2), Gauri Nagar (23.23 m^2), and Maharaja Chatrasal (23.71 m^2).

   The majority of these wards are situated in the middle part of the city. Prominent locations such as Indore G.P.O., Central Jail, Polo Ground, and Laxmibai Nagar Railway Station are located within this category. These wards have a mix of residential and commercial land use.

   Currently, the per person open space availability is sufficient in these wards. However, it is anticipated that vacant plots will develop into built-up structures, leading to an increase in population and a subsequent decrease in the per capita availability. Proper planning and sustainable strategies are required to ensure the increase and maintenance of open and green spaces in these wards for the future.

5. **High Availability of Per Person Open Space:** There are 14 wards in this category, where the per person open space availability ranges from 33.6 m^2 to 73.61 m^2 . The wards falling within this range include Bhagwati Nagar (33.6 m^2), Chitavad (34.2 m^2), Sauth Tukoganj (34.9 m^2), Shahid Bhagat Singh (36.94 m^2), Shyam Nagar (38.8 m^2), Brajeshwari (39.2 m^2), Sirpur (41.13 m^2), Ashok Nagar (43.53 m^2), Choithram (43.61 m^2), Sai Krupa (45.38 m^2), Residency (46.8 m^2), Vishnupuri (47.6 m^2), Prajapat Nagar (50.14m^2), and Nahar Shahvali (73.61m^2).

   These wards are located in the middle part of the city and share boundaries with outer wards that have high availability of open space. The land-utilization pattern in these wards has a combination of residential and commercial.

   However, there is adequate per capita open space availability in these wards, but at the same time, they are at very high risk of encroachment on available open spaces due to the conversion of significant agricultural lands into residential and commercial built-up areas. In absence of proper attention, these open spaces may be lost due to the impact of increasing urbanization, leading to a reduction in per capita availability of open spaces.

6. **Very High Availability of Per Person Open Space:** There are 10 wards in the city that fall in this category. The per person availability of open space ranges between 101.5 m^2 to 777.3 m^2 , which is nearly 60 times more than the required standard. These wards are Vishwakarma (101.5 m^2), Nand Bagh (103.1 m^2), Sant Kabir (25.4 m^2), Palda (209.5 m^2), Nipaniya (284.8 m^2), Lasudiya Mori (332.9 m^2), Sukh Niwas (378 m^2), Bilawali (525 m^2), Bijasan (538 m^2), and Mundala Nayata (777 m^2). These

wards are located in the outer periphery of the city. The land-utilization pattern in these wards is combination of rural and urban characteristics, because they were villages that were added to the city's municipal area in 2014.

On one side, these wards feature significant amount of agriculture and vacant land, while on the other, they are rapidly transforming into built-up structures. This conversion is likely to change the high adequacy of available open space into very low availability in the coming years. However, at present, they still have wide green belts. These green belts (agriculture land) are essential open spaces that help protect the city from the harmful impacts of increasing urbanization by contributing to improved air quality as they act as a buffer against air pollution. Conserving these green belts can also help prevent the city from further expansion.

Summary: The analysis of open space distribution in the city indicates a clear pattern that the amount of open space increases as we move from the city center towards the outer areas. This pattern is driven by factors such as historical development, urbanization, and land availability. In the central parts of the city, where development occurred earlier and space was limited, there tends to be a scarcity of open spaces. As we move towards the outer parts, there are more open spaces, resulting in larger and more varied forms.

Out of 85 wards, there are **49 wards** in the city where the per capita availability of open space falls below the recommended $12m^2$ /person standard. These wards are primarily located in the center and middle parts of the city, where open space has become scarce, particularly in the Central Business District (CBD) and its surroundings. These wards are in an alarming state, requiring urgent measures to increase green areas. Wards situated in the middle-outer parts of the city currently have sufficient open space. However, plans are needed to preserve these available open spaces and accommodate the growing population in a sustainable manner. Lastly, the outer parts of the city currently have adequate open space. Nevertheless, these areas are not free from the pressures of increasing urbanization. These are more susceptible to conversion into built-up structures. Proper planning can ensure the preservation of these open spaces and promote sustainable development, particularly in terms of preserving open/green spaces.

Suggestions: Indore metro city has a strong economic base, and it attracts both capital and labor. The city also experiences high population growth. Growth is an underrated process. Efficient and planned allocation of open space and infrastructure ensures a sustainable urban environment. The following measure should be maintained in the city to make the city green and healthy.

- **Vertical Greenery:** In the wards where there is no horizontal space available to increase greenery or open space, very strenuous efforts will be required to meet the greenery standard of 12m2 per person. This can be achieved by developing rooftop gardens and vertical gardens must be made a mandatory feature for every floor of buildings. Every available space, including balconies, baramdas, and both sides of major roads and streets, must be utilized for planting vegetation. Only then can air quality be improved to some extent in these wards.
- **Horizontal Greenery:** In the wards where open space is available (such as parks, playgrounds, mela maidans, green belts, rows of trees, water bodies, crematorium/burial grounds, and other open spaces), efforts should be made to increase greenery by planting dense rows of trees along their boundaries.
- **Conservation of Agricultural Green Belts:** These green belts are located in the outermost part of the city. They are rapidly being converted into built-up areas due to the outward growth and the lack of space in the central parts of the city. The city's expansion is encroaching upon these surrounding agricultural areas. Protecting these agricultural lands has become essential for the urban environment of the city. These agricultural lands offer extensive areas for polluted air to disperse freely and become free of pollutants.
- **Water Bodies:** A significant area of water bodies has been lost due to encroachment. Efforts should be made to increase their size and depth. These water bodies should be converted into bird sanctuaries, wetlands, and recreation areas. Access by the public should be restricted inside these areas.

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