City Space Architecture

A Digital Blueprint of Breathing Spaces in Mumbai

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Abstract

Mumbai, amongst the most densely populated cities in India, offers an alarming ratio of 1.24 square meters of public open space per capita (MCGM, 2016, p. 70). The negligence in the provision and protection of public open spaces in the city's recent Development Plan 2034 further exacerbates this deficiency. The lack of comprehensive guidelines and policy frameworks for efficient tracking, monitoring and management makes it extremely difficult to ensure the safety of these breathing spaces in the city. Public open spaces are further endangered owing to ill maintenance and heavy encroachments. The research underlying this paper outlines a strategic framework for developing a digital inventory of open spaces designated by the Municipal Corporation of Greater Mumbai (MCGM). This framework is intended to facilitate the management and monitoring of these areas[1]. By annotating descriptive, quantitative, and analytical parameters, the study begins with an exhaustive ground survey of around 634 public open spaces in the suburban areas of Mumbai. The research critically evaluates the collated survey data and employs a GIS mapping methodology for geospatial analysis. Finally, it aims to make the inventory readily available to all stakeholders and citizens through digital tools and platforms that allow real-time engagement with local communities. The focus of this paper is on the role of digital tools in creating a repository available on an open-source platform that can help identify issues with public open spaces and encourage public participation in preserving and improving open spaces in the city with respect to health, safety, and comfort. The database created based on the survey focuses on governance, accessibility, safety, encroachments, and design aspects. The findings from the study will help navigate the issues of public open spaces in dense urban conglomerations like Mumbai.

Keywords: GIS analysis, community participation, digital toolkit, inequalities, urban policy

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Abbreviations

DCPR	Development Control & Promotion Regulations
DP	Development Plan
EOS	Existing Open Spaces
MCGM	Municipal Corporation of Greater Mumbai
NGO	Non-Government Organisation
RDDP	Revised Draft Development Plan
PG	Playground
POS	Public Open Spaces
RG	Recreation Ground
ROS	Reserved Open Spaces
SRA	Slum Rehabilitation Authority
URDPFI	Urban and Regional Development Plans Formulation and Implementation
MHADA	Maharashtra Housing and Area Development Authority
NBC	National Building Codes of India
SPA	Special Planning Authority

1. An introduction to public open spaces in Mumbai

Mumbai's transition from seven separate islands to a continuous landmass by the early 20th century, achieved through extensive land reclamation, has reshaped its geological structure and urban fabric. This transformation has not only altered the city's physical environment but has also had significant impacts on its infrastructure, land use patterns, and overall urban development. Initially restricted to the island city, the limits of Greater Mumbai have spread to include a vast metropolitan area stretching towards the north. This expansion now covers western and eastern suburban areas and reflects the city's substantial growth and urban sprawl over the years. According to the 2011 census, Mumbai's population density has reached 20, 634 per sq. km making it one of the most densely populated cities in the world (Maharashtra, 2014). The city is grappling with significant pressure on its limited land resources as it tries to accommodate its ever-growing population. The high population density has led to overcrowding in many suburban areas; this is evident in the presence of informal settlements and slums in the city (Yadav & Bhagat, 2017, p. 273).

The quality of life is further affected by the significant reduction in public open spaces (POS) and natural areas (NA). Public open spaces are essential amenities that provide residents with areas for recreation, social interaction, exercise, and connection with nature (MCGM, 2016, p. 147). The total area of all types of natural areas and open spaces in Mumbai amounts to 128.41 square kilometres (Figure 3), which translates to an average per capita open space availability of 10.32 square meters. However, a substantial portion of these open spaces is not accessible to much of the population. As mentioned in the Development Plan, of the total open space, only 15.37 square kilometres is publicly accessible, meaning they are available for entry by all citizens or local communities. This provides a per capita POS availability of just 1.24 square meters (MCGM, 2016, p. 70).

The limited accessibility of open spaces highlights a critical issue: the actual amount of POS available for public use is much smaller, affecting the quality of life for residents and their access to recreational and social areas. When compared to various national and international guidelines, Mumbai's availability of POS is significantly below the recommended standard (Figure 4). For instance, the Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines in India suggest a minimum of 10-12 square meters per person of open space. Mumbai falls short of this benchmark (Development, 2015, p. 362).

The accessible POS comprises different types of open spaces such as gardens, playgrounds, recreation grounds, beaches, promenades, sports complexes, botanical gardens and green belts. These open spaces are further categorised under two divisions:

Existing Open Spaces (EOS)	Reserved Open Spaces (ROS)
Open spaces that are acquired by the government and are developed for the purpose of sports, recreation, social, and cultural activities.	The parcels of land that are reserved as open spaces but are yet to be acquired by the government. Most of these plots are under private ownership. These are expected to be acquired by 2034.
Categories of EOS and ROS as per DP 2034 Tank/Pond/Lake, Promenade, Beach, Playground, Garden/park, Club/Gymkhana, Swimming Pool, Zoo, Municipal Sports Complex, Sports Complex/Stadium, Recreation Ground, Green Belt, Botanical Garden	

Figure 1. Different Categories of Public Open Spaces as stated in the Development Plan 2034
(Source: RDDP 2034)

As stated earlier, Mumbai offers only 1.24 square meters of public open space per capita, a total of 15.37 square kilometres of POS spread across the city's 25 wards. The distribution of these spaces is uneven, with certain wards, particularly in South Mumbai, providing having significantly more POS than the suburbs. Figure 4 shows this disparity, where population of each administrative ward (census 2011) is compared against the availability of open space per capita. Administrative Wards A, B, and D in the Island City offer over 4 square meters per capita, far above the city average. This disparity can be attributed to historical, socio-economic, and planning factors. During colonial times, South Mumbai was the centre of power, trade, and administration. Creation of vast open spaces originated from that time. Large government and institutional campuses, along with docks and naval areas, contributed to a higher number of open spaces and green cover in this part
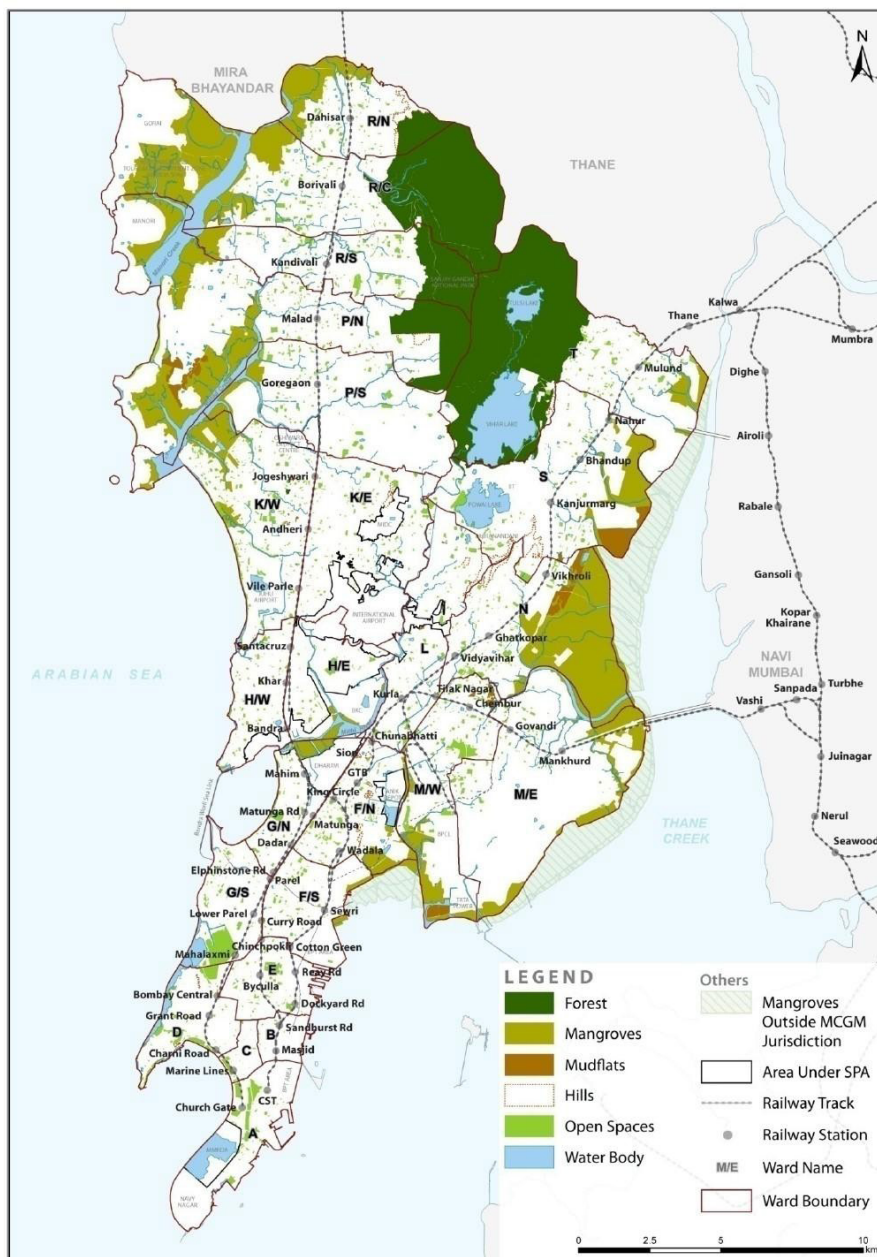

Figure 2. Existing natural areas and open spaces in Mumbai (Source: RDDP 2034)

International and National Definitions and Standards for POS

Authority	Definition	POS Standard sq.m./capita
WHO World Health Organisation	Areas of land or water, publicly/privately owned that are a. accessible to the general public b. free of charge/with a minimum fee c. used for recreational/social purposes/for the enjoyment of nature.	9 sq.m/capita
Minisrtry of Housing and Urban Affairs, India	As per URDPFI, open spaces can include three categories a. Recreational space b. Organised green c. Other common spaces (vacant lands/ flood plains, forest cover etc in plain areas)	10-12 sq.m/capita
National Building Code (NBC) India	The NBC does not explicitly define the open spaces	3 sq.m/capita
Report to Draft Development Plan	Public Open Spaces (POS) as those open spaces (OS) where there is right to access and any restrictions imposed are universally applicable. Open spaces that are available to all members of a local community, such as residents of a housing society, are local community spaces. So are clubs, gymkhanas and swimming pools that are available on membership or fee basis. However, since a sizeable number of citizens enjoy such spaces, the RDDP has treated them as Public Open Spaces.	4 sq.m/capita for Mumbai

Per capita open space availability in Indian cities

21.5 sq.m/capita **New Delhi**   17.3 sq.m/capita **Bangalore**   1.24 sq.m/capita **Mumbai**   0.81 sq.m/capita **Chennai**
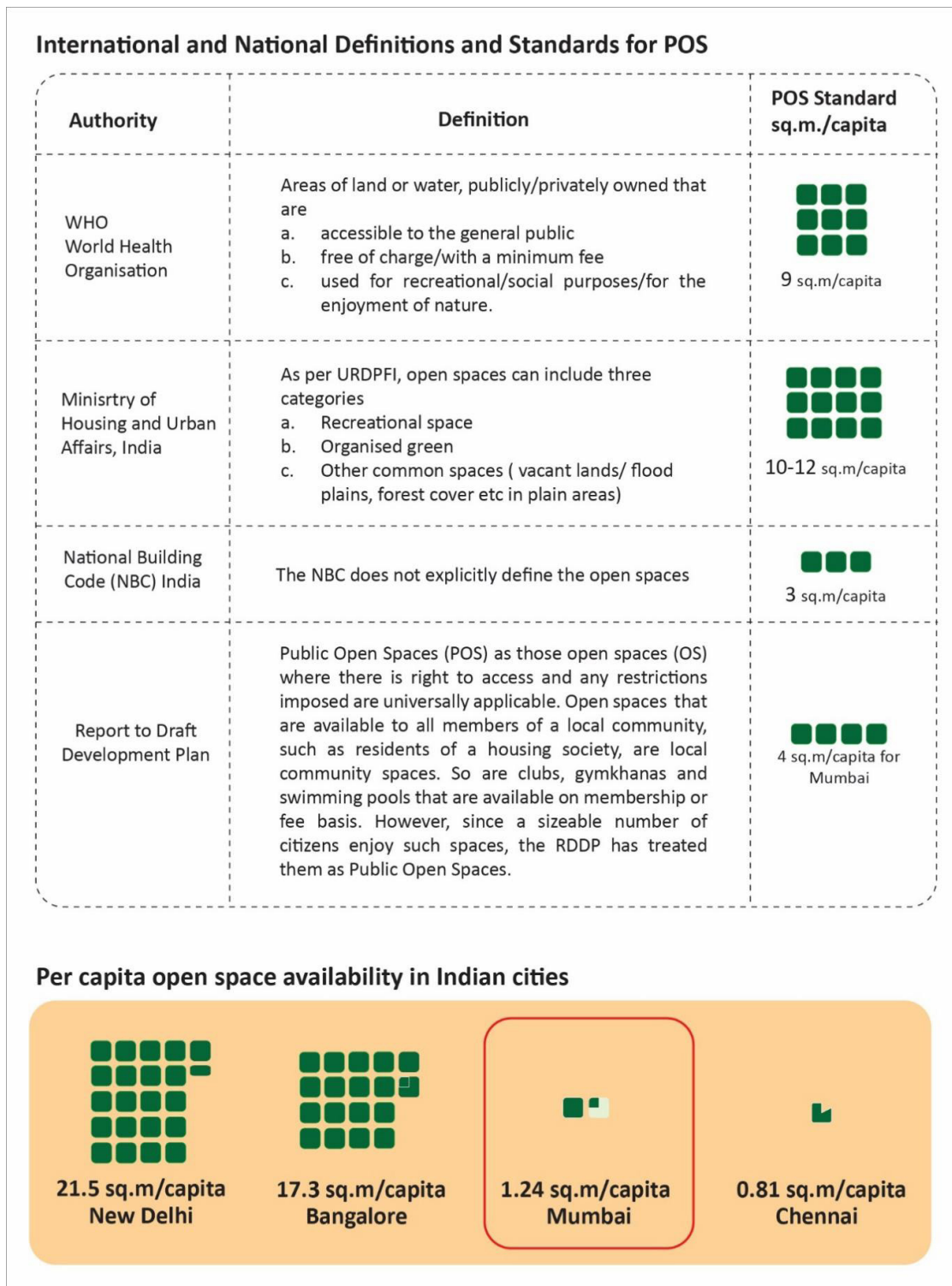
Figure 3. Standards for open spaces: Definitions and per capita availability (Source: Diagram by authors from (Udas-Mankikar, 2020), (MCGM, 2016))

of the city. While South Mumbai was planned with considerations for open spaces, the suburbs which expanded rapidly post-independence, often grew without comprehensive urban planning. The expansion was driven by the need to accommodate rapidly growing population, leading to dense, unplanned settlements, with little room and less priority for public open spaces. A stark difference between 'A' Ward and H/E Ward highlights this imbalance. While 'A' Ward offers 9.4 square meters per person with a low population density of fewer than 20,000 people per square kilometre, H/E Ward provides only 1.1 square meters per person, with a much higher population density of 60,000-80,000 people per square kilometre.
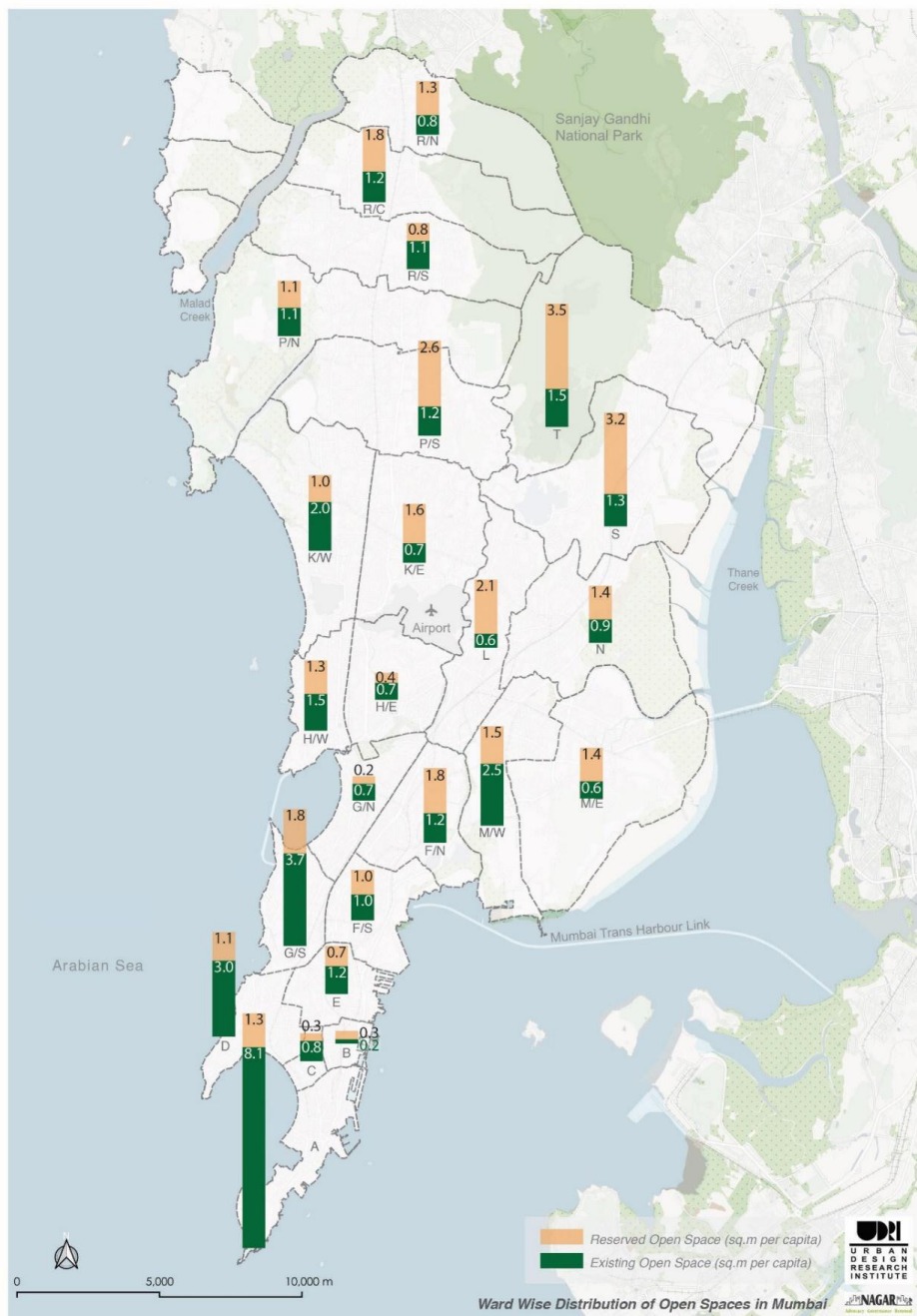
Figure 4. Ward-wise availability of open spaces (Existing Open Spaces and Reserved Open Spaces) per capita (Source: Diagram by authors created from the RDDP 2034 document data)

2. Background of POS mapping in Mumbai

When discussing the issue of POS, it is important to note the declining green areas in the city. The total green cover in Mumbai has significantly reduced from 46.42% in 1988 to 26.67% in 2018, and the areas of Land Surface Temperature (LST) higher than 30.50 °C have increased from 5232 ha in 1988 to 14, 339 ha in 2018 (Rahaman et al., 2020, p. 8). The city's green and natural areas have been affected by rapid urbanisation, a high migration rate, inadequate housing, and a series of city infrastructure projects over the past decade. This scarcity of green areas makes open spaces even more crucial. Also, a lack of political will to acquire lands for Open Space amenity has had an adverse effect on the future of open spaces in the city (Adarkar, 2015, p. 9). Similar patterns of degrading conditions of open spaces are observed across many cities in India. Several studies and projects in other Indian cities primarily focused on environmental, planning, and social perspectives. For example, an assessment of POS in Nagpur city was done to evaluate qualitative aspects of POS (Ahirrao and Khan, 2021), Chennai's urban greens were studied to evaluate environmental impact (Sundaram, 2011), a study on evaluation of urban green spaces in Pune was carried out to understand changing patterns of land use (Padigala, 2012).

With respect to Mumbai, previous studies focused on objectives to enhance the quality of natural areas and open spaces and to facilitate participatory governance practices in the city (Figure 5). Projects done prior to 2019 evaluated open spaces that were designated in the 1991-2010 Development Plan. The project 'Breathing Spaces' by CitiSpace, provided an extensive fact file on 600 Reserved Open Spaces in Greater Mumbai (CitiSpace, 2012), while a comprehensive study on POS highlighting key issues and recommendations was conducted by the Mumbai Metropolitan Region – Environment Improvement Society (MMR-EIS) in collaboration with Neera Adarkar. Despite these evaluations, there has been no focus on how to update this information. Given that observations are time-specific, open spaces have experienced various changes, including modifications, due to new Development Plans.

The latest Development of Mumbai, DP 2034, was released in 2018 and this was a major turning point as the formulation of DP put special emphasis on creating better guidelines for protection of public open spaces (MCGM, 2016, p. 96). What was changed in the latest DP was the integration of 'environmental areas' by changing the definition of public open spaces (Udas-Mankikar, 2020, p. 3). The Municipal Corporation of Greater Mumbai (MCGM) released the Development Plan 2034 in 2018, along with the Revised Draft of the Development Plan (RDDP) and the Development Control and Promotion Regulation (DCPR), which detailed the new policies[2]. A GIS interface called 'DP Remarks 2034' was also made available online, marking all reservations and providing basic information about these designations[3]. Apart from the DCPR and RDDP documents, this portal is the sole open-access repository provided by MCGM. However, the information on this portal is limited and is not updated frequently. It is the MCGM's responsibility to ensure the safety and maintenance of these spaces. The best way to achieve this goal requires active collaboration of citizens, civil society, and the private stakeholders (UN-Habitat, 2018, p. 6). Building on previous studies, this paper investigates the state of open spaces as outlined in the latest Development Plan 2014-34 (DP 2034). The study utilised the relevant documents from the MCGM official website to assess the condition of both Existing

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[2] https://portal.mcgm.gov.in/irj/portal/anonymous/qlcedpdocs
[3] https://dpremarks.mcgm.gov.in/dp2034/

Open Spaces (EOS) and Reserved Open Spaces (ROS). This evaluation focuses on two administrative wards within Greater Mumbai: K-West and P-North. By integrating the latest data and designations from the Development Plan, the study provides a comprehensive understanding of the current status and utilisation of these open spaces.

3. Focus of the paper

The focus of the paper is on the role of digital tools in developing conscious citizen participation in dealing with public open spaces in the city. The research proposes a specific methodology to develop a digital repository of Public Open spaces. To demonstrate this process, the study collates data through surveys of a total of 634 Public Open Spaces (EOS + ROS) open spaces in K-West and P-North Wards. The database created from the survey findings focuses on governance, accessibility, safety and design parameters that affect the quality of open spaces.

The pilot wards, K-West and P-North are situated in the western suburbs of the city (Figure 2). These wards were selected for their diverse range of open spaces in terms of their natural and functional characteristics. Over the years, both the wards have experienced significant growth in residential developments. K-West Ward is home to a long coastal stretch, extending from Juhu Koliwada to Versova, covering a distance of eight kilometres. This expansive beach area is a major recreational asset for the city's
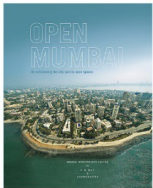
Open Space Mapping Projects Conducted in Mumbai

	2010 **Breathing Spaces** *by CitiSpace*	*A fact file on state of 600 open spaces. Highlighted issues of encroachment, management and access*
	2011 **Open Mumbai** Re-envisioning the city and it's open spaces *by PK Das & Associates*	*Consisted of Detailed Mapping of open space and comprehensive plans for their improvement.*
	2012 **Inventorisation of Open Spaces and Water Bodies in Greater Mumbai** *by Neera Adarkar Associates + MMREIS*	*Identified issues with open spaces and water bodies in Mumbai through detailed on-ground surveys, mapping and data analysis.*
	2021 **The HARITA Project** *by Project Mumbai and Ministry of Mumbai's Magic*	*Mapping gardens and recreational grounds in wards of Mumbai to create awareness and youth engagement*

Figure 5. Key Projects on open spaces in Mumbai (Source: projects websites)

residents. On the other hand, P-North Ward is distinguished by its large natural areas. It encompasses significant ecological features, including mangroves and natural parks located at both the eastern and western ends of the ward.

In the study, a total of 634 open spaces were surveyed, with 347 Public Open Spaces (POS) from K-West Ward and 289 POS from P-North Ward. The survey encompassed both Existing Open Spaces (EOS) and Reserved Open Spaces (ROS). The primary aim of this documentation was to assess the conditions and availability of these open spaces within the wards, offering valuable insights into their current status and their role in serving the local communities.
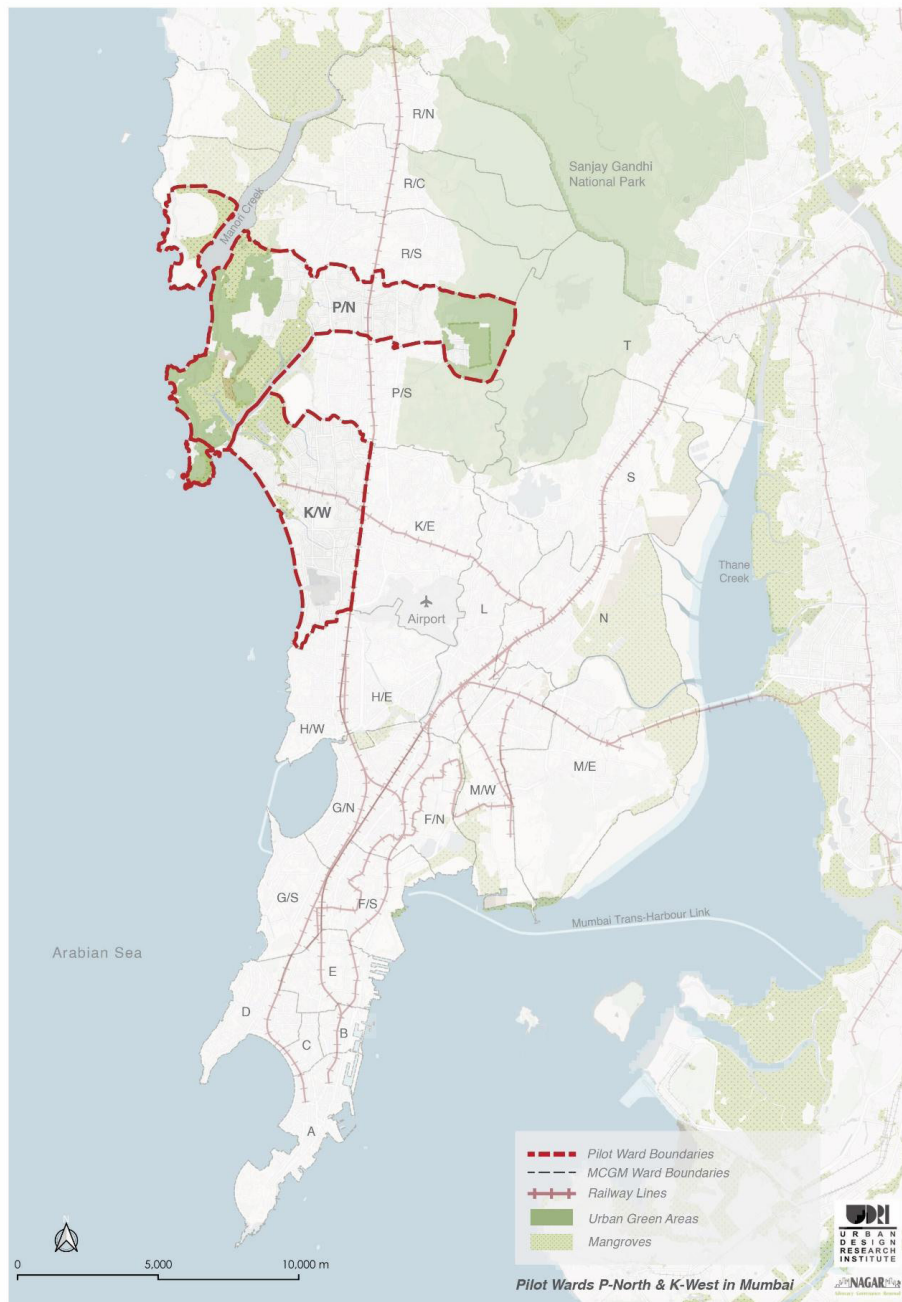

Figure 6. Pilot Wards K-West (K/W) and P-North (P/N) taken as the pilot wards for the research (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

For this assessment, various digital tools were used, ensuring a streamlined and efficient methodology. This approach not only aids in understanding the current state of public open spaces but also establishes a replicable framework that can be applied city-wide for evaluating public open space conditions. The assessment is done at two levels. First, we analyse the existing conditions concerning access and issues discrepancies between actual conditions and what is shown on the Development Plans of the city. Secondly, we have analysed design-related parameters that affect the quality and overall user experience.
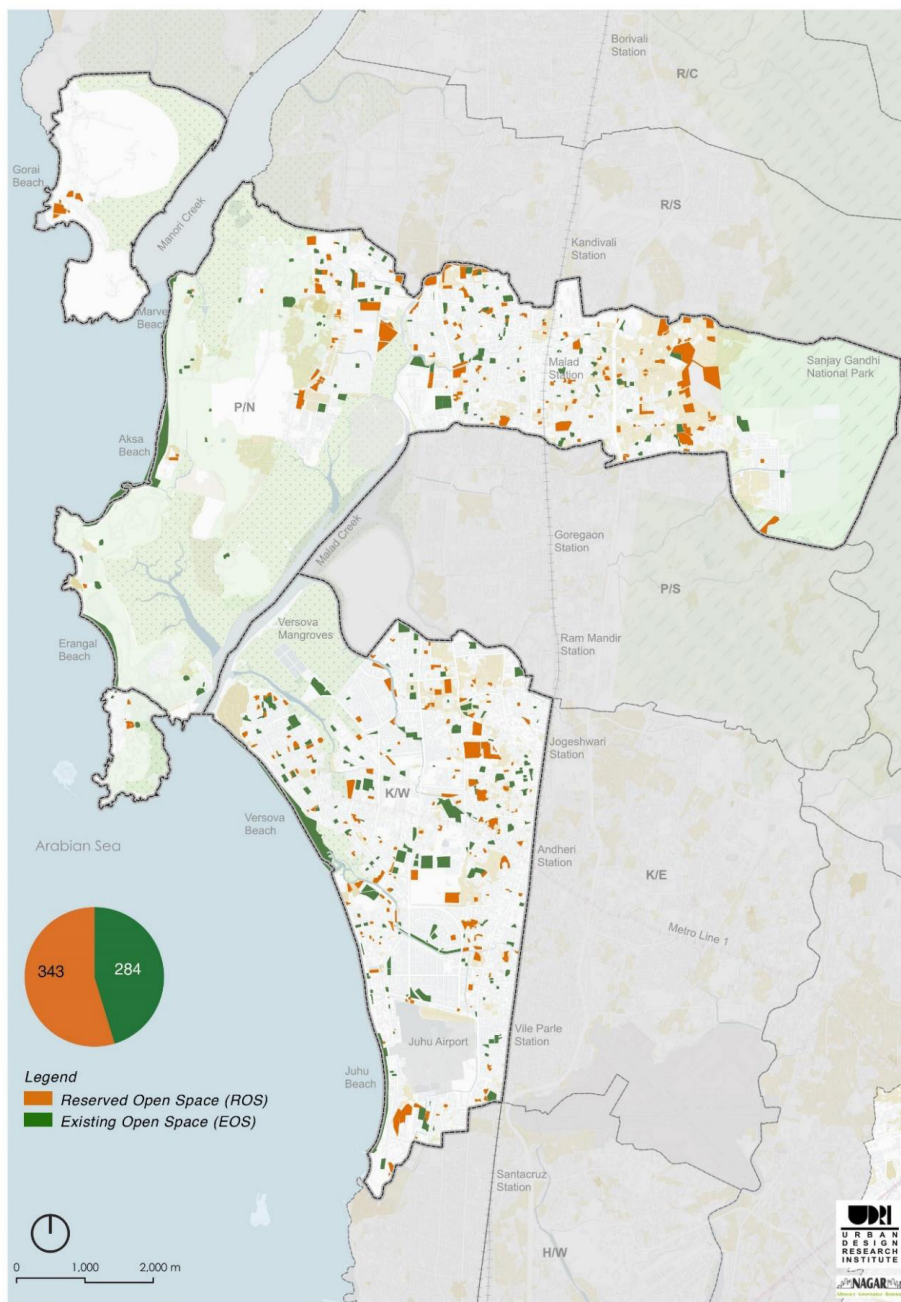

Figure 7. A total of 634 Existing Open Spaces (EOS) and Reserved Open Spaces (ROS) in K-West P-North Wards (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

4. Mapping and documentation of POS

For the documentation of public open spaces, open-source software like QGIS, Google Forms, Google My Maps, and Google Spreadsheets were used to capture and manage data. Google Forms was used to collect structured observations and survey responses, addressing quantitative parameters. Google My Maps is used to spatially represent the surveyed open spaces, making it easier to visualise and analyse their condition. Google Spreadsheets are then used to organise and analyse the collected data in QGIS. The choice of these tools is driven by their efficiency and accessibility, ensuring that the documentation process is streamlined and that a wide range of participants can engage in and contribute to the enhancement of POS. A survey team comprising students was trained to conduct the survey of each site using these tools. With the use of individual site maps, DP Plan and digital proforma, site surveys of 634 sites were conducted. With the help of photographs, videos and sketches, the actual conditions of the POS were documented on Google My Maps (Figure 7).

Post the mapping and documentation stage, the spatial analysis involved consolidating the survey data into GIS to uncover different analysis patterns. In addition to the primary data layers generated by the mapping project, some extra layers of urban spatial data were incorporated and overlaid to facilitate a comprehensive analysis. Through this process, overarching concerns and specific gaps were identified. The collected data was analysed through statistical findings, spatial analysis through maps and graphs, and the creation of a scoring matrix for rating and analysis.
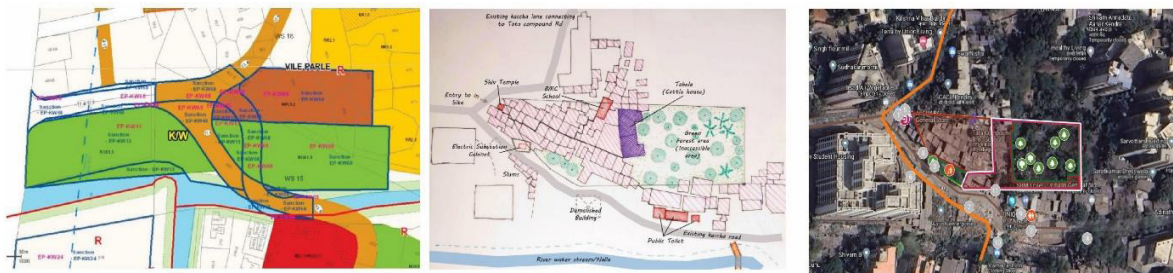

Figure 8. Stages of documenting site conditions, from the study of DP to creating Google My Maps (Source: Diagram by authors created from the survey data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)
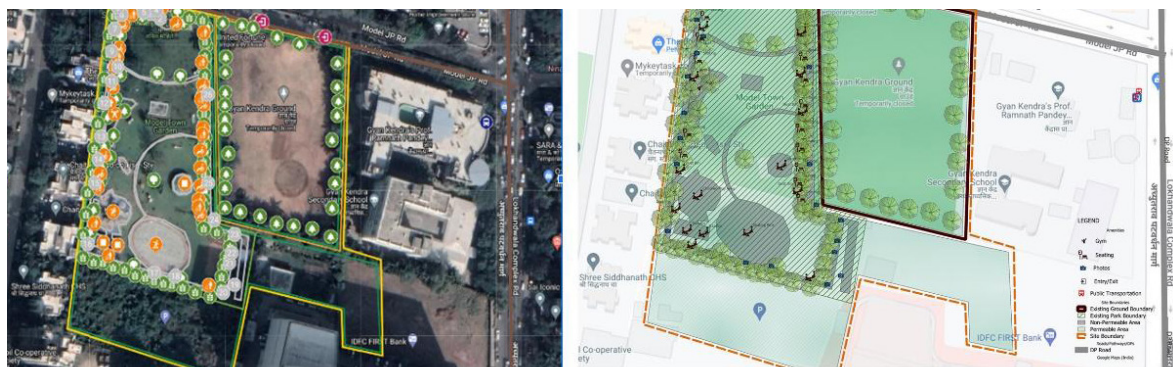

Figure 9. Digitisation of Survey data by first creating the layout in Google My Maps and then transferring the layers into the GIS database (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

5. Research Findings

After consolidating the survey data of the open spaces in pilot wards into various GIS layers, we identified the key issues like discrepancies between the details shown in the development plan (DP) and the actual condition, access problems, various restrictions, and missing design elements limiting usability. These findings highlighted a substantial disparity between the Development Plan's portrayal of public open spaces and their actual conditions.

6. Issues with the Reserved Open Spaces (ROS)

6.1 Reserved Open Spaces occupied by Informal settlements and slums

Out of 634 public open spaces in the pilot wards, 343 sites are Reserved Open Spaces (ROS) - more than 50% of total reservations under POS (Figure 7). The City's current Development Plan (DP 2034) aims to secure all these reserved areas by 2034. This process involves acquiring land from private owners when these plots are earmarked for public use. However, a review of the 1991 and 2034 Development Plans shows that many plots designated as Reserved Open Spaces (ROS) since 1991 remain occupied by slums, with no progress towards their acquisition or development (Figure 9). In the pilot wards, 100 out of 343 ROS are now occupied by informal settlements or slums, with 89 designated as ROS since 1991 without any changes or development (Figure 11). The continued designation of these slum-occupied plots as ROS, particularly those unchanged since 1991, highlights a major inconsistency in DP implementation and necessitates revision. The plots occupied by slums are already high-density areas that also lack open spaces. As POSs promote various kinds of activities and functions, in such contexts, these spaces can become a symbolic element of civic engagement and citizenship (UN-Habitat, 2016, p. 32).

7. Issues with the Existing Open Spaces (EOS)

284 sites out of 634 sites in the surveyed pilot wards are Existing Open Spaces (EOS)

DP 1991 (Site Area: 13011.56 sq.m)   DP 2034 (Site Area: 12944 sq.m)   Google imagery
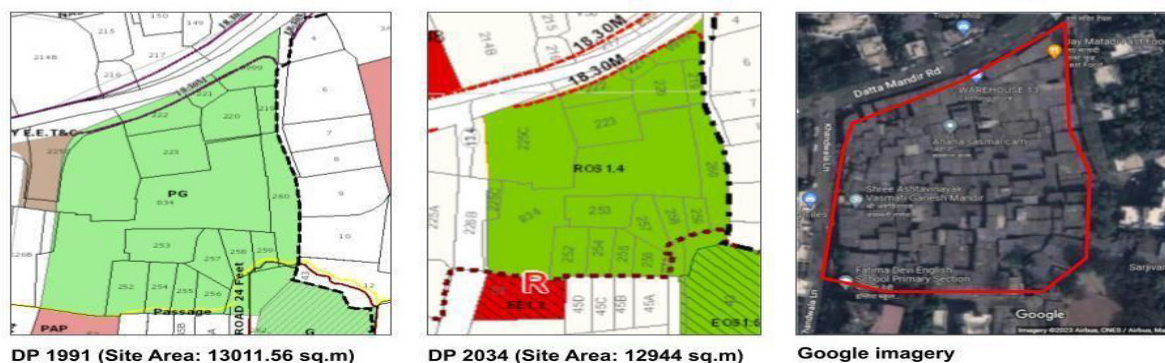
P/N Ward: Plot with informal settlements designated as Playground (ROS 1.4) since 1991

Figure 10. An informal Settlement designated as ROS 1.4 (Playground) since 1991 (Source: Authors)

(Figure 7). These open spaces are intended to be government-owned and developed, as defined in the development plan. Yet, many issues were observed hindering access, usability and overall experience of the open spaces.

7.1 Discrepancies in Designated vs. Existing Usage and Areas

The DP 2034 outlines open spaces on two levels: first, by designating plots for open space land use and second, by specifying the intended functions for these spaces. Errors in defining or assigning the use of Existing Open Spaces (EOS) can lead to imbalances in providing the necessary amenities as planned. Currently, 63 sites have been found where
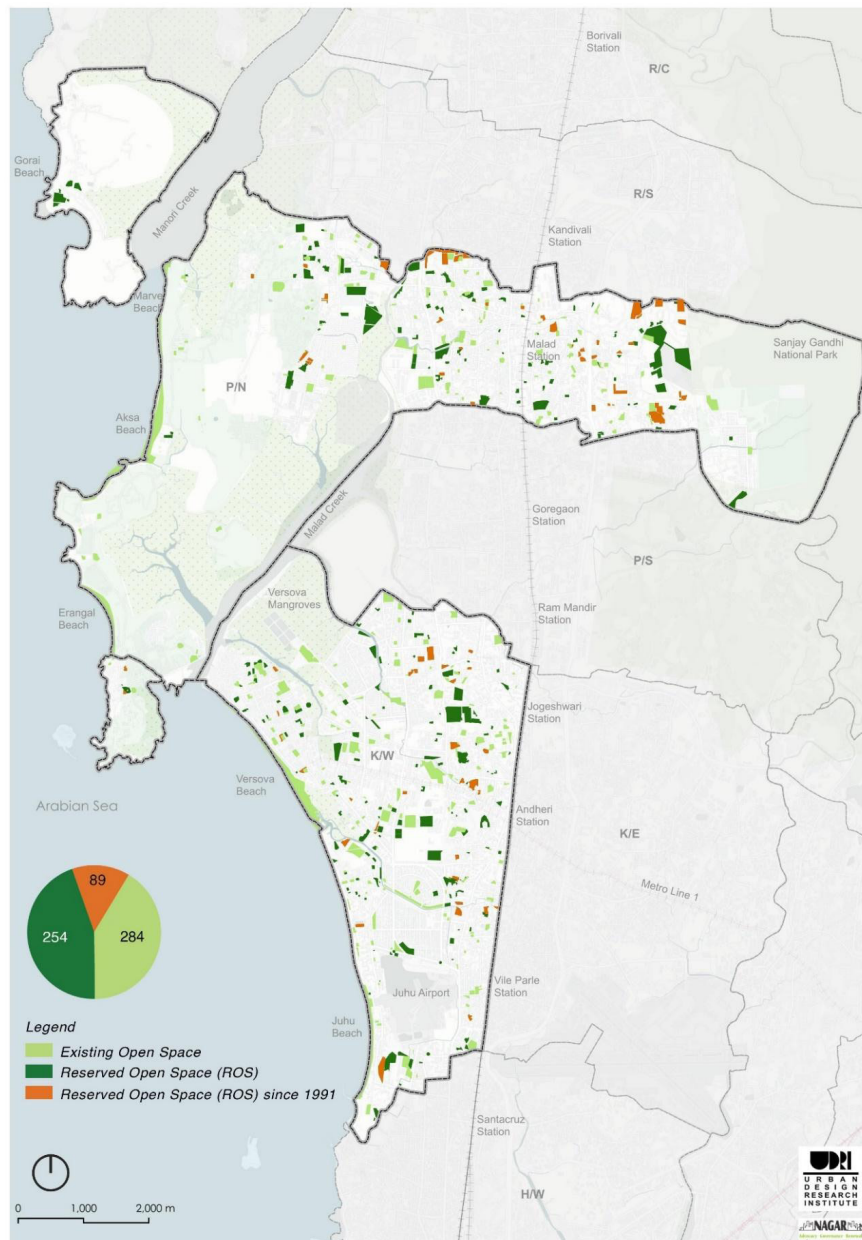

Figure 11. ROS occupied by slums since 1991 (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)
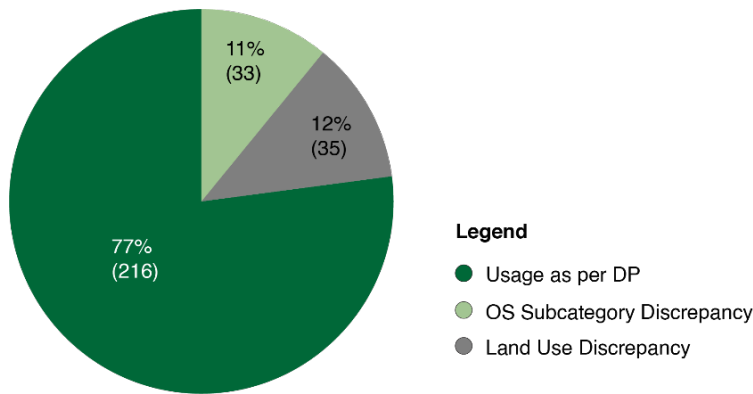
Figure 12. Number of Existing Open Spaces with usage discrepancies
(Source: Diagram by authors created from the survey data of 'Public Open Space Mapping in Mumbai' project undertaken by UDRI and NAGAR NGO)

the actual usage deviates from the designated uses in the development plan.

In addition to usage discrepancies, we also identified issues with the area calculations of open spaces. By comparing the site areas measured during surveys with those delineated in the development plan, we discovered inconsistencies. We found discrepancies in both the total area and boundary delineation. Sites with significant differences - exceeding 300 square meters - have been flagged for further attention. The survey revealed that 45 sites in the pilot wards exhibit errors in area delineation (Figure 13). It was observed that the loss of open space area is primarily due to residential encroachment. The table below illustrates the area loss experienced by the pilot wards due to discrepancies in delineating open space boundaries. In total, 13% of the existing open space—equivalent to 56, 752 square meters or 5.67 hectares—has been lost due to these delineation errors in the two pilot wards.

Wards	No. of Sites	Area Loss
K-West	25	20857 sq.m
P-North	20	35895 sq.m
Total	**45**	**56752 sq.m – 13 %**

Figure 13. Loss in total area of existing open spaces due to discrepancies in area calculation (source: survey data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

8. Access and restrictions

The survey also highlighted issues related to access to the existing open spaces (EOS). In general, accessibility can be measured based on the walking distance via the road networks, the management and maintenance of POS, amount of money charged for entering the space, the time which the open space is open for, and the infrastructure available to access the open space including those for the persons with disabilities (City-

Wide Public Space Assessment Toolkit, 2020). Due to the limitations of the conducted survey, we classified the open spaces into three categories based on the nature of access with the following parameters:

Accessible Sites	Sites that can be accessed via a usable DP-designated road and allow unrestricted use for all[4].
Partially Accessible Sites	Sites that have filters in place before granting entry are identified as partially accessible. The filters could be 1. An entry fee – For Parks and recreation grounds 2. Membership and fee payment – for Clubs and Gymkhanas 3. Layout RG's - admitting only people living within the layouts 4. School Playgrounds – accessible to school students and at limited hours.
Inaccessible Sites	Inaccessible sites are those which cannot be accessed or used by people. These include natural spaces, reclaimed lands, privately owned plots, encroached and occupied sites, sites without road access, or if they are not developed and in poor condition.

102/284 EOS in the pilot wards are inaccessible as these sites are either occupied by slums or are used for other purposes such as commercial shops, vendors, hawkers, garbage dumping, and religious activities (Figure 15). Some EOSs also remain undeveloped, despite being vacant. Seventeen such EOS sites are inaccessible for various reasons, including being locked, abandoned, used for dumping garbage or construction materials,

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[4] We emphasise the importance of DP Designated roads as these roads are officially designated in the development plan, they are protected from being privatised or repurposed for individual use. DP-designated roads serve as key pathways that facilitate entry for everyone to open spaces.

Figure 14. Dattaram Narayan Kasker Udyan in the K-West ward has 2500sq.m out of the DP demarcated park area being used as an MCGM-operated water treatment plant (source: Diagram by authors from the survey data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO.)
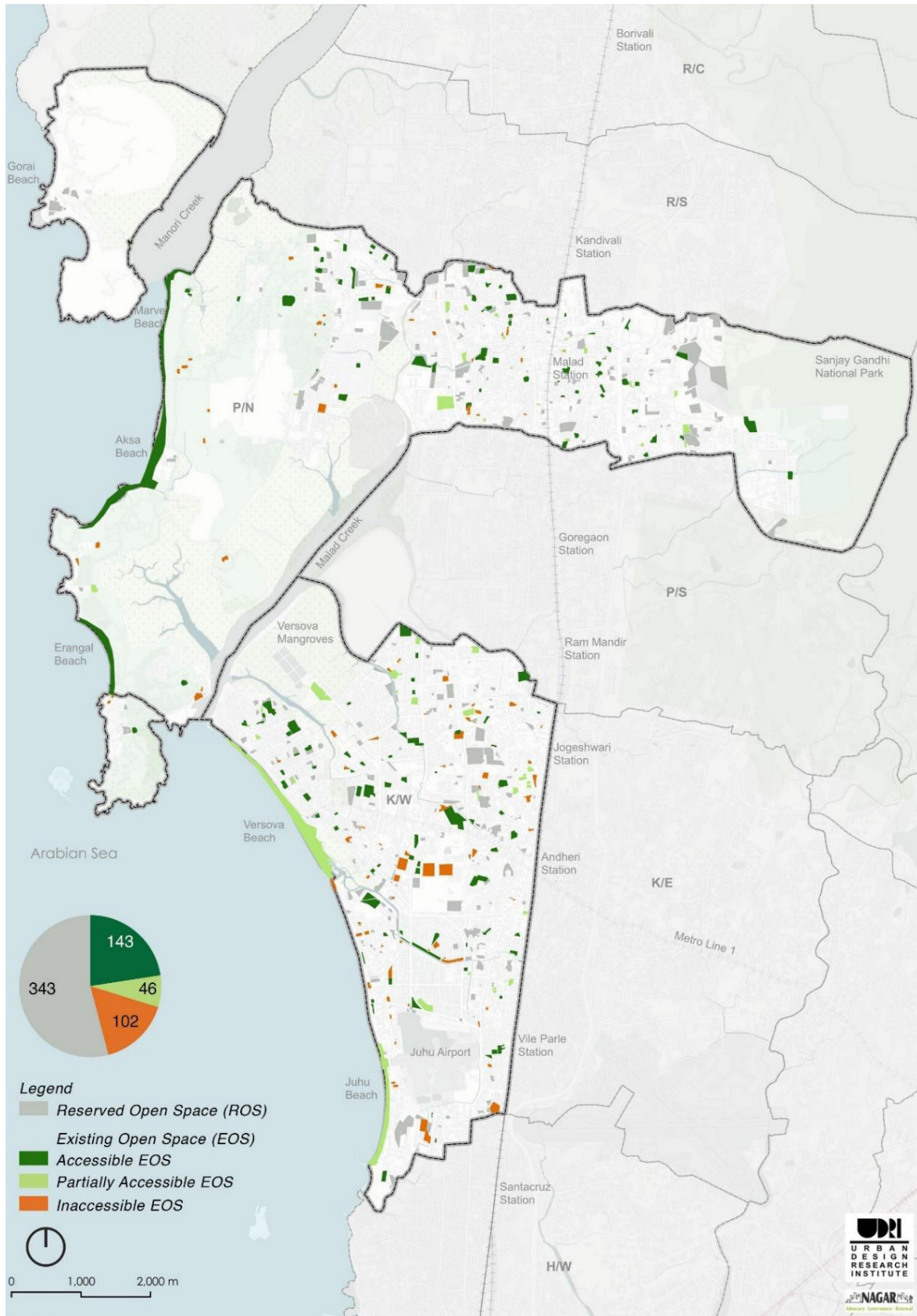
Figure 15. Accessible, Partially Accessible and Inaccessible EOS in pilot wards
(Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project
undertaken by UDRI and NAGAR NGO)

overgrown with vegetation, or utilised as parking spaces. Such conditions render these sites unsuitable for any recreational open space use.

Existing open spaces in the pilot wards are under MCGM, State Government, Central Government, or private ownership (Figure 17). In the K-West ward the number of public open spaces under private ownership were higher than those owned by the MCGM, while in the P-North Ward, public open spaces under MCGM ownership were higher than those under the private ownership. We also see that the ownership of the POS is directly linked to its access (Figure 17). The majority of open spaces owned by MCGM and other government authorities are generally more accessible to the public in comparison to privately owned sites. Although some privately-owned open spaces are well-developed and maintained, they often have restricted access, limiting usage to a select group of individuals. Most of privately-owned open spaces are under private residential societies, clubs, playgrounds and sports facilities with access limited to members. Clubs with private ownership are observed to be imposing timing and monetary restrictions. The access to such spaces is limited to clubs/gymkhana/sports facility members. While entry fees should
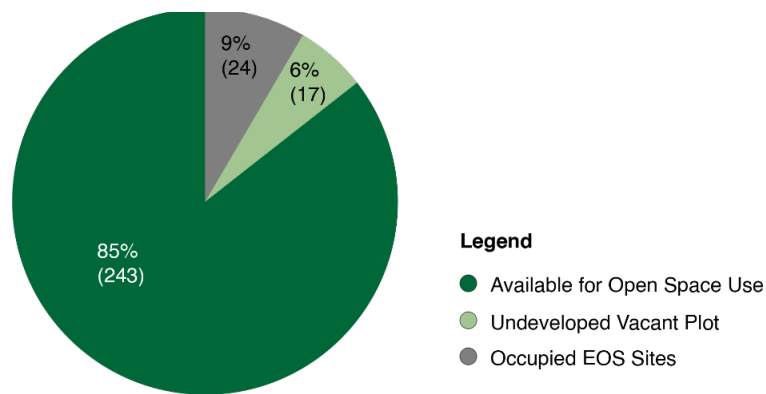

Figure 16 Physical conditions of EOS affecting access (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)
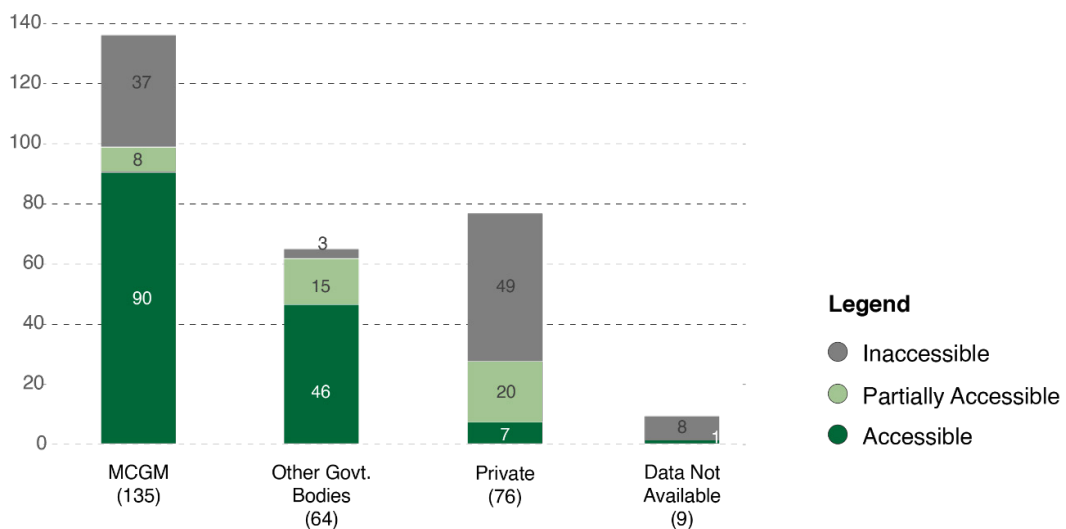

Figure 17. Ownership of EOS affects the access to the open spaces
(Source: Diagram by authors created from the data of the 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

be avoided to ensure easy access, minimal fees are charged for providing specialised facilities in open spaces. Few gardens and parks under MCGM ownership are observed to have minimum entrance fees. Playgrounds and open spaces with sports facilities charge fees to access the amenities. The highest charges are observed in the open spaces where there are privately owned clubs/gymkhanas present.

Safe and comfortable access to open space is ensured when the authority regulating open spaces also manages access roads into it. For public open spaces in Mumbai, it is important that MCGM provides a DP road as these roads offer equitable access to everyone. Moreover, any type of encroachment on DP-designated roads is strictly prohibited.

This ensures long term upkeep and monitoring. The survey observed that there are many sites where a DP road is proposed; such sites were being accessed through private roads, leading to inaccessibility of POS.

For the evaluation of design aspects concerning health, safety and comfort, 143 Existing Open Spaces (EOS), that are both developed and accessible to all, are analysed.

9. Design aspects for health, safety and comfort

The rudimentary characteristics of public open spaces include a safe, clean and welcoming environment that promotes social and physical activities, is well-maintained and engages the community (Anon., n.d.). Based on these primary characteristics of any open space, the study has identified four essential dimensions to evaluate the 143 accessible EOSs. An open space must cater to these following four functions through Elements of Design.

1. Safety and Security
    Open space users range from toddlers and children to elderly and women. For the vulnerable and their caregivers, the sense of safety and security in the open space becomes the foremost deciding factor on choosing to access it. In this study the dimension of providing 'safety and security' within an open space is thus considered the most important with 40% weightage on the scoring index.

2. Comfort and Usability
    The ease of using and sense of comfort experienced in an open space decides if the user will visit that space again. An open space should have basic amenities that make the use of it convenient and comfortable. Thus, on the scoring index usability and comfort has the second priority with a 25% weightage on the scoring index.

3. Sustainability and Resilience
    Parameters of sustainability and resilience include greening efforts, tree cover and vegetation and natural features. These indicators not only impact immediate perception of the space but also have a larger impact on resilience in the neighbourhood. The quality of these parameters has a positive impact on the mental perception of such spaces, nudging people to engage with these spaces and protect them.

4. Health and Hygiene
    The final dimension for scoring a public open space is health and hygiene. The level of cleanliness of the area and its amenities like toilet blocks dictate the amount of time one spends in the open space. Public open spaces with inefficient management of waste

Scoring the Dimensions	Breakup of Score	Indicator	Sub-Indicator
40% **Safety & Security**	10	Entrance Signage Board	Does the Open Space have a visible entrance signage?
			Are the ownership & management details specified?
	10	Boundary Wall	Is a physical boundary demarcation present?
			Does the boundary allow visual access?
	10	Lighting	Does the open space have lighting?
			Is the available lighting optimal?
	6	Security Guard	Does the Open Space have security guards at all times?
			Do the security personnel have dedicated security cabin?
	4	CCTV Surveillance	Does the Open Space have functional CCTV surveillance?
25% **Usability & Comfort**	5	Seating and Benches	Is there sufficient seating in the open space?
	5	Daytime Shading Device	Are there measures taken to provide shaded areas?
	5	Sidewalks	Does the open space have unbroken sidewalks?
	5	Walking Track/ Pathway	Does the open space have continuous pathways?
			Is the pathway of non-skid material?
	2.5	Informational Signages	Does the open space have signages with clear instruction on operation of open space?
	2.5	Blockage Free Sidewalk	Is the sidewalk free of blockages?
20% **Sustainable Design**	8	Permeability	How much area of the ground is permeable?
	8	Vegetation Cover	How much area has vegetation cover?
	2	Rain Water Harvesting	Does the open space have rain water harvesting mechanisms?
	2	Solar Light	Does the open space use solar energy for lighting?
15% **Health & Hygiene**	6	Waste Disposal	Does the open space waste gets disposed regularly?
	6	Dustbins	Is the open space serviced by dustbins?
			Are the dustbins segregated?
	1.5	First Aid Kit	Is there a first aid kit available on-site?
	1.5	Toilet Block	Is there a toilet block in close proximity to the open space?
			Is it clean and well maintained?

Figure 18. Analysis parameters (Source: Authors)

and instances of littering and unclean or unhygienic conditions discourage people from using that space.

The indicators for evaluation were identified based on the physical amenities observed on most of the accessible Existing Open Spaces in K-West and P-North wards during the survey[5]. They were categorised in the dimension in which they had the most impact. A scorecard for each EOS was created by rating them based on the survey observations.

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[5] There are many other parameters that enhances the quality of open spaces, Due to the limitation of the survey which does not capture perception-based data, the study only examines quantitative parameters for the purpose of this study.
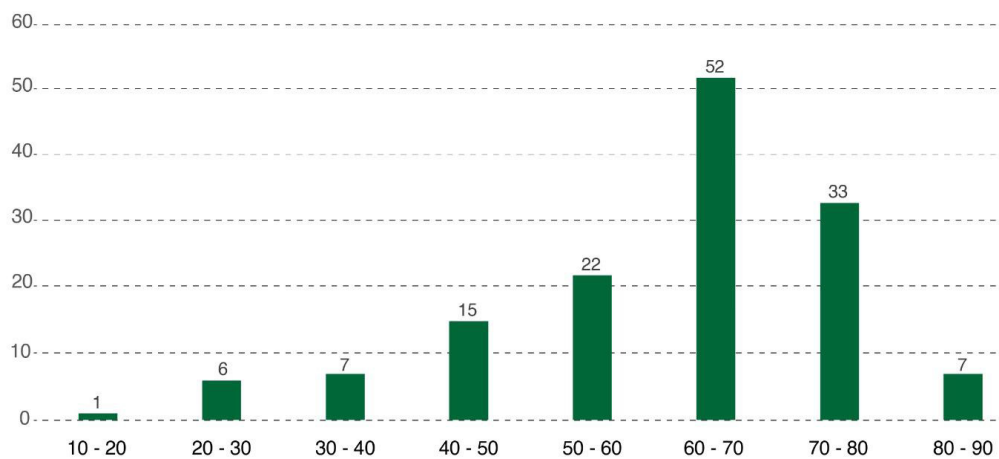
Figure 19. Range of Scores derived for EOS in the Pilot Wards, the lowest score of 18.6 and the highest score of 86.6 was calculated showing the range of (Source: Diagram by authors created from the data of 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

These observations for the parameters were quantified/simplified into best, worst and base cases or were put either put into ranges for ease of scoring.
The four dimensions and their corresponding indicators are shown in the Figure 18 with the reasoning for the scoring. The accessible EOS sites are scored on a scale of 0-100 based on the weightage allotted to each parameter as seen in Figure 18.

10. Condition of Open Spaces

Scoring the EOSs based on the amenities available within the open spaces showed a vast disparity in their conditions. Of the 634 sites initially mapped as per the DP 2034, only 143 are accessible EOSs. However, despite being accessible, they are not up to the basic mark of providing safety, comfort, and hygiene.

51 sites out of 143 scored less than 60 points; this indicates they are performing poorly in the provision of basic amenities that render an open space safe and usable (Figure 16). 85 sites are performing in the mid-range with a score ranging 60 to 80. These sites are usable, however can improve to provide comfort and resilience.

Only seven sites are performing well when it comes to providing basic amenities. These 7 sites have scored above 80. For example, Kaifi Azmi and Kishor Kumar Park in K-West Ward were excellent examples performing well in scoring of usability and comfort parameters providing well designed seating area and shading devices. General signage and instruction boards with MCGM logos indicating ownership were also installed in these two sites (Figure 20). Similarly, Sheila Raheja Park in P-North ward provides well maintained amenities like children's play area, toilets, and attractive landscape elements (Figure 21).

However, none of the sites scored more than 90. This indicates that open spaces in pilot wards of Greater Mumbai are struggling to provide basic amenities that render an open space usable. Figure 22 and 23 highlight the sites with lowest scores with poor site conditions. These sites received scores less than 21 with very few parameters checked such as permeability and defined boundaries.

Figure 20. Kaifi Azmi and Kishor Kumar Park in K-West Ward with a score of 86.6 (source: photos by survey team for the project 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

Figure 21. Sheila Raheja Park in P/N Ward with a score of 86.6 (source: photos by survey team for the project 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

Figure 22. EOS in K-West Ward with a score of 20.5 (source: photos by survey team for the project 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

Figure 23. EOS in P-North Ward with a score of 18.4 (source: photos by survey team for the project 'Public Open Space Mappin in Mumbai' project undertaken by UDRI and NAGAR NGO)

11. Discussion

The observation and analysis of the collated data of open spaces in K-West and P-North ward has highlighted the persisting issues with these public open spaces, in addition to the need for concurrent mapping using digital tools. The analysis of the data is a reminder that for land uses like open spaces, the data collation has to be done beyond just spatial parameters of area and extent. It should also reflect parameters such as ownership, access and a catalogue of amenities - missing and present.

Using simple digital analytical tools, factors affecting access and use of an open space were identified - like private ownership and management, vacant plots awaiting development, and encroachment. However, a thorough inspection of open spaces needs the data to be the most concurrent. The data available in the public domain through independent research carried out by think tanks and research groups are outdates and thus have become redundant. There is a need for a city-wide digital repository of open spaces as new age digital tools streamline the process of data management, updating, storage, and sharing and save time and effort.

Currently, MCGM has the most concurrent spatial data for city-wide open spaces, but it neither captures aspects of physical conditions nor available amenities nor is it available in the public domain. The unavailability of data makes it difficult for stakeholders to engage with public open space issues. Having publicly available digitised data can help think tanks and academic institutions to undertake the task of formulating novel solutions to deal with

urban open space issues and develop policies that can safeguard and promote them. Having the data in public domain also welcomes citizen efforts towards constant updating of such repositories by raising queries and concerns. A fine example of citizens raising their concern through digital platforms for open spaces in their cities is the 'Privately Owned Public Space in New York City' website[6]. The website provides important information about the open spaces, providing a crowd-sourcing vehicle to the public to post their observations, share photos and videos and suggest changes (Kayden & The Municipal Art Society of New York, 2012).

Mumbai, a city of civic action, has seen multiple legal battles, advocacy campaigns with respect to open spaces. The citizens not only exercise their right to question the authorities but also present their rights to open spaces. The efforts of restoring the Jawaharlal Nehru Garden led by the Nariman Point Churchgate Citizens Association (NPCCA) or the Save Rani Bagh Movement by the Save Rani Bagh Botanical Garden Foundation, or the constant effort of the OVAL Trust to maintain and protect the Oval Maidan and Cross Garden (UDRI, 2024) are testimony to the citizen's will and grit to engage and work with the government and actively participate in safeguarding the common goods- public open spaces.

Such civic action and movements find momentum when there is data transparency and availability. Having a publicly available database that gives all concurrent information allows people to actively participate and take up specific issues with their governing bodies and builds trust between them, where each contributes to the upkeep of open space. The transparency and ease of relaying their issues to the government make the vigilant citizens engage in natural surveillance or watchdogs safeguarding the public amenity of open spaces. The synergy thus created ensures long term maintenance and a strong partnership between the provider – the government, and the end user – the citizens.

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