Geospatial Technique to make Indian Cities Accessible for Persons with Disabilities

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ABSTRACT:

Accessibility is realized when individuals with specific mobility, visual, auditory, or cognitive requirements can navigate and utilize the built environment with minimal need for adaptation. In India, almost twenty-seven million people live with some form of disability (census 2011). Between 2001 and 2011, the total number of persons with disabilities in India increased by 22.41%. Notably, the urban population with disabilities saw a rise of 48.21%, compared to just 13.72% in rural areas. This disparity emphasizes the urgent need to enhance accessibility in Indian cities for persons with disabilities. According to the National Sample Survey (2018), 85.5% of persons with disabilities in urban areas had trouble accessing public transportation, while 61.7% encountered challenges in accessing public buildings. These findings highlight the critical need to enhance the accessibility of the built environment in urban India. In this research, the potential of geospatial approach has been explored to assess universal accessibility of Indian cities taking Bhopal as case study city. Bhopal city is a tier II city in the state of Madhya Pradesh in India. This study devises a method to prepare GIS maps using access audit results which will show zones of high, moderate, and low accessibility in the context of mobility of a visitor with disabilities. These maps will help to identify part of the city falling within zones of low and moderate accessibility and the reason behind it. Another advantage of using GIS will be customized maps for each disability type can be prepared and the outcome will be generalized for other relevant cities. Geospatial maps will be used for spatial planning to make Bhopal accessible.

1. Introduction

Disability and accessibility are both complex phenomena (Lid, 2016). Disability arises when there is a disconnect between an individual's abilities and the demands imposed by the environment (Buhalis et al., 2010). Accessibility can be attained by enhancing individual capabilities—such as through education, rehabilitation, and personal assistance—alongside implementing modifications in the environment to accommodate people with disabilities. The concept of universal design first emerged in western countries long back during the 1970s and 1980s, but in India, it is a relatively new concept (Khare et. al., 2014). A key milestone came in 2011, when Indian designers and thinkers formalized the Universal Design India Principles (UDIP). In India, disability is fundamentally shaped by poverty, rural residential patterns, and social disparities (Saha et. al., 2022).

This study evaluates the universal accessibility of Bhopal by analyzing the mobility of visitors with disabilities through the application of Multiple Criteria Evaluation (MCE) within a GIS framework.

1.1. Background study

Universal design refers to the creation of environments and products that are accessible and usable by all individuals to the maximum extent feasible, without requiring additional adaptation or specialized solutions (Lusher et al., 1989). There are several barriers and constraints faced by people with disability in a city including physical access constraints. Though several scholars (Daniels et al., 2005; Darcy, 1998; Darcy et.al., 2002; Ernawati et. al., 2005) have worked on accessibility assessment of built environment, application of MCE technique in GIS environment is minimal (Saha et.al. 2025).

The MCE methodology has been applied within GIS, specifically in the realm of map overlay analysis. In his work in 1999, Malczewski delves into the GIS-based modeling of spatial multicriteria problems, employing principles and decision analysis techniques. Mayordomo-Martínez et al. (2019) created a mobile web application designed to aid individuals with disabilities by providing information on beach accessibility in the Murcia region of Spain. Their analysis revealed that approximately one-third of the examined beaches exhibited high accessibility, while another third lacked any accessibility features. Alzouby (2019) applied Multi-Criteria Decision Analysis (MCDA) within a geospatial framework on the outskirts of the Irbid Municipal Area in Jordan and found that persons with disabilities are often confined to their homes, which ultimately impacts their social lives. Israeli (2002) evaluated the importance of accessibility factors among fifty disabled tourists at different tourist sites in Israel. The study found that disabled tourists modified their site visitation preferences based on their accessibility experiences, including challenges such as bathrooms without adequate facilities for disabled visitors. Church (2003) proposed an innovative measure of accessibility that considers the diverse needs of individuals with different abilities. Traditional measures often overlook structural obstacles and individual mobility constraints, which influence travel time, physical exertion, and the capacity to complete a journey. Church's analysis introduced several accessibility frameworks, such as 'absolute access,' 'gross access,' 'closest assignment access,' 'single and multiple activity access,' 'probabilistic choice access,' and 'relative access.' It was recommended to use relative access in conjunction with absolute access in a cost-effective way to improve accessibility for individuals with disabilities.

The methodology adopted in this research for assessing Accessible Tourism in Bhopal closely aligns with the GIS-based Multiple Criteria Evaluation (MCE) technique described earlier.

1.2. Measuring disability in India

In India, nationwide disability statistics primarily come from two official sources: the Census of India and the National Sample Survey (NSS). While the Census provides a complete enumeration of the population, the NSS collects data through a nationally representative stratified sampling method (Saha et. al., 2025). The National Sample Survey (NSS) programme, launched in 1969 by the Ministry of Statistics and Programme Implementation, Government of India, was established to gather micro-level data. The NSS conducts a disability survey every 11 years, with the most recent one carried out in 2018. The Census has included a disability-related question in selected years, with the most recent instance in 2011 (Mitra et.al., 2006). As both the Census and NSS gather disability data at national, state, and district levels, this study utilizes data at the district level. There are almost twenty-seven million people living in India with some form of disability, which constitutes 2.21 percent of India's total population (Census of India, 2011).

1.3. Need for Accessibility Assessment in Bhopal City, Madhya Pradesh

Madhya Pradesh (MP) ranks third among states in number of total disabled population in India (Census, 2011). MP contains 8.87% of total disabled population of India, 6.01% of which is male and 2.86% is female. According to the 2011 census, Bhopal district ranks first among all districts of MP in terms of percent of disabled population to total population. Bhopal district has 84,502 people with disabilities, which is 3.56% of the district's total population. In Bhopal district, 87% of total disabled population lives in urban areas. According to census 2011, Bhopal Municipal Corporation (BMC) has 14,491 persons with disability which is 17.15% of total disabled population of Bhopal district. The disability types include locomotor disability, blindness, hearing impairment, speech and language disability etc. Locomotor disability dominates (41.33%) among the disability types. In urban Bhopal, 58% of surveyed persons with disabilities reported experiencing difficulties in accessing public transportation, while 61% indicated challenges in accessing public buildings (NSS, 2018). The challenges encountered included the absence of ramps or lifts, difficulty in opening doors, inadequate seating arrangements in waiting areas, obstacles at service points, lack of specialized toilet seats, and the unavailability of signage for directions, instructions, or public announcements (NSS, 2018). The Indian law requires that all public buildings and places must be accessible to all people including seniors and those with disabilities (RPwD Act, 2016) but the Census data (2011) mentioned above highlights the lack of implementation of the act in Bhopal district. There is a need of making urban areas of Bhopal district accessible in general and Bhopal Municipal Corporation area in particular, as 17.06% of districts total disabled population live within corporation area.

1.4. Proposed methodology for the study

In this study, the complete road network of Bhopal city was digitized using a GIS platform, and an accessibility audit was conducted employing custom-designed checklists tailored to the Indian context. Two separate checklists were prepared to assess Universal Accessibility at City Entry Points and Public Realm points. The Multiple Criteria Evaluation (MCE) technique within a GIS environment was employed, producing a map that illustrates the hierarchy of accessible zones. These maps depict the spatial distribution of the built environment within Bhopal city that performs well in universal accessibility assessments compared to others. An area classified as highly accessible may nonetheless be deficient in one or more universal access standards. Proposals have been developed according to whether a specific parameter requires *New Construction* or *Retrofitting* or *Operation* or *Maintenance* based on the relative percentage of each parameter at each site. While *New Construction* means building from scratch, *Retrofitting* means upgrading existing structures. *Operation* means activating a parameter with minimal intervention and *Maintenance* means proper care of existing infrastructure.

2. Checklists Preparation for Auditing Universal Accessibility

To prepare universal accessibility checklists both International and National checklists were referenced. Among the international checklists, 'Access-improving the accessibility of historic buildings and places' (2011), 'Code of Practice-on Accessibility of Public Services and Information' provided by Public Bodies–National Disability Authority, Dublin, Ireland (2006) was consulted. For Indian references, the 'Harmonized Guidelines' and 'Standards for Universal Accessibility in India' (2021) published by the *Ministry of Housing and Urban Affair*s, Government of India was consulted. The guidelines helped to select parameters and sub-parameters related to physical built environment to be included in the audit checklists. During the development of the checklists, the disabilities considered included cognitive impairment, complete blindness, elderly individuals, hearing impairment, limb disabilities, partial blindness, speech impairment, and wheelchair users. Two types of checklists were developed, namely:

1.Checklist for *City Entry Points*- This checklist was created to audit the universal accessibility of roads at key city entry points, including railway stations and bus stands. Each parameter in the checklist is examined through corresponding indicators that provide detailed criteria essential for ensuring the parameter's accessibility.

2. Checklist for *Public Realms*- This checklist was designed to audit the universal accessibility of road segments from City Entry Points to Accommodation Points, as well as from Accommodation Points to Tourist Sites.

Table1. Spatial parameters identified for Access Audit Checklists

Parameters exclusive for City Entry Point checklist	Parameters exclusive for Public realm Point checklist
1.Reservation and information counters, 2. Platforms (train), 3. Toilet Facility, 4. Seating Area , 5. Stairs, 6. Lifts, 7.Walks and paths	1.Approach to monument/structure 2.Planned Pedestrian routes 3. Barriers and hazards, 4. Parking Space, 5. Suways and foot over bridge, 6.Traffic signal
Common parameters	
Kerb Ramps, Ramps, Tactile Guiding & warning blocks, Signages	

In checklists, each parameter will have sub parameters ranging from five to thirty.

3. Selection of Road Sections for Universal Access Audit

Given that this study focused on evaluating universal accessibility and enhancing accessibility in Bhopal city, the road network of Bhopal played a crucial role.

3.1. Introduction to Bhopal city

Bhopal is situated in the heart of India within Madhya Pradesh state (fig.1). The city was built during eleventh century by the then king *Raja Bhoj*. It is the capital of the state ranking second in terms of population. It ranks 16th in India with a population of 18,86,000 (Census 2011). In this study, the limits of the Bhopal Municipal Corporation (BMC) were used to define the boundary of Bhopal city (fig. 1), and it covers 285sqkm of area.

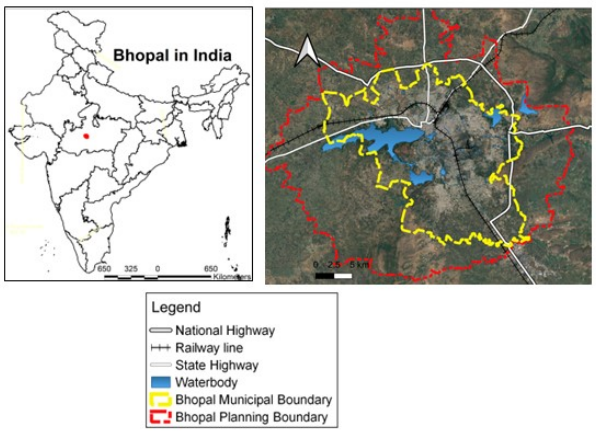

Figure 1. Location of Bhopal in India and tourist places in Bhopal

Road sections for universal access audit were selected referring to the draft Bhopal Development Plan (BDP) of 2031 published by Town and Country Planning, Madhya Pradesh. and the footfall data. A continuous road network of 36.8km length covering tourist sites, accommodation points and city entry points were selected for accessibility audit survey covering 19 municipal wards (smallest administrative unit in city). The land use found along the road stretch are commercial, residential, mixed use, recreational, public and semi-public. There are three main city entry point clusters in Bhopal city, each of which consists of a railway station and a bus stand. The clusters are:

A. *Bairagarh Railway Station* and *Halalpur* bus stand located at the city periphery (fig. 2).

B. *Bhopal Railway station* and *Nadra* bus stand which is located at the core city of Bhopal (fig. 2).

C. *Rani Kamlapati Railway Station* and the Bus Terminus for intercity bus transport situated at the newer part of the city (fig. 2).

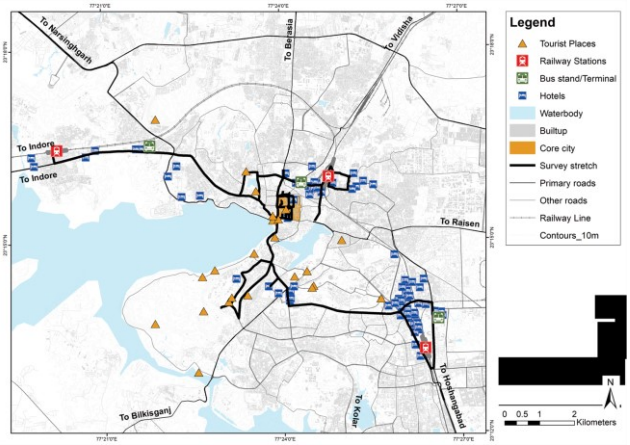

Figure 2: Selected Road Sections within Bhopal City

4. Physical Survey Using Audit Checklists

It's often difficult for someone without a disability to fully comprehend the intrinsic aspects of mobility assistance required by individuals with disabilities. Students participated in simulation exercises under the guidance of domain experts and then were sent to the field for data collection through physical survey. The survey sheet was digitized using the 'Epicollect5' application, a free and user-friendly mobile and web platform for data collection (http://five.epicollect.net). The access audit checklist for spatial components contained parameters and sub parameters. Each parameter was assigned a numerical value—for instance, a value of 1 if the parameter is present, 0.5 if partially present, and 0 if absent. Data points were collected at 20-50m intervals along the road sections. For city entry points data was collected at 150 points and for public realm, data was collected at 130 points.

5. Data Analysis Through GIS

The GIS analysis was carried out through a sequence of four steps, like the MCE method described by Heywood et al. (2006). Initially, the survey data collected via the Epicollect App was imported into the GIS platform. Next, the relative accessibility percentages for each parameter were computed within the GIS environment. Following this, thematic maps representing each accessibility parameter were created. Finally, specific weights were assigned to these parameters, and an overlay analysis was performed. The overlay map shows zones of accessibility in Bhopal city in the categories of high, medium and low accessible zones.

5.1. Importing data in GIS platform

To bring the data to the GIS platform, the survey data is downloaded in .csv format. The data is opened the ArcMap browser and using 'Add data button' added the extracted .csv file in the ArcMap browser. Using the 'Display XY data' tool the data is displayed as point files in the ArcMap browser by assigning latitude and longitudes. The survey data is displayed in terms of points in GIS browser. The points were exported in the shape file format and saved. The road network of Bhopal city has been digitized using the GIS (ArcGIS Desktop, V. 10.6), with survey points overlaid onto the map.

5.2. Calculation of Relative Percentage Score

Because each parameter contains a different number of sub-parameters, it was necessary to normalize the total score obtained for each parameter. For that purpose, the relative percentage of accessibility score for each parameter for a particular site is calculated for both Public Realm and City Entry Point. Table 2 shows example of calculation in the attribute table of point shape files for City Entry Point. Same has been done for public realm.

5.3. Generation of thematic maps for each accessibility parameter

After calculating the relative percentage, the next step would be creating choropleth map for each parameter. Choropleth maps for each parameter were generated using the Inverse Distance Weighted (IDW) interpolation function in GIS. IDW generates a continuous surface by assigning weights to sample points that diminish inversely with distance (ArcGIS Desktop Help).

Table 2: Relative Percentage Score for accessibility - City Entry Points

SN	*Location Name*	*P 1**	*P2**	*P3**	*P4**	*P5**	*P6**
1	**Halhalpur Bus Depot**	0	0	0	77	75	0
2	**Bairagarh Station Platform 1**	0	77	70	79	50	0
3	**Rani Kamlapati Station**	0	95	20	94	100	100
		P7*	***P8****	***P9****	***P10****	***P11****	
1	**Halhalpur Bus Depot**	0	0	54	0	0	
2	**Bairagarh Station_ Platform 1**	0	0	0	100	0	
3	**Rani Kamlapati Station**	100	100	87	0	0	

RP 1*- Reservation and information counters
RP2*- Toilet facility
RP3*- platforms (train)
RP4*- Signages
RP5*- Seating Area
RP 6*- Kerb ramps
RP7*- Ramps
RP8*- Walks and paths
RP9*- Stairs
RP10*- Lifts
RP11*- Tactile Guiding & warning blocks

nearby observations exert the greatest influence, resulting in a more detailed (less smooth) surface when compared to methods with broader smoothing. On these IDW-derived maps, elevated interpolated values correspond to higher levels of accessibility for the parameter under investigation. Figure 3 displays the IDW output for the *Kerb Ramp* parameter.

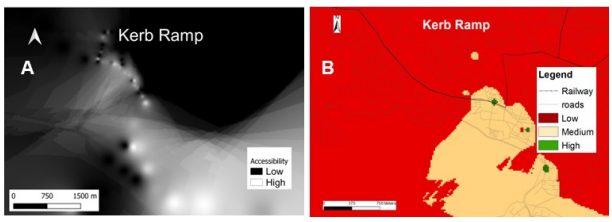

Figure 3. A. IDW map of 'Kerb Ramp', B. Reclassified image of 'Kerb Ramp'

The IDW output was further processed through 'Reclassify' function in GIS and zones with high, medium, and low levels of the accessibility were created. Fig 4 shows the universal accessibility status of city entry points in eleven accessibility parameters. According to figure 4, among City Entry Point clusters, Cluster C containing Rani Kamlapati Railway Station and the Bus Terminus for intercity bus transport popularly known as Inter State Bus Terminus (Refer section 3.1) scores highest in most of the parameters.

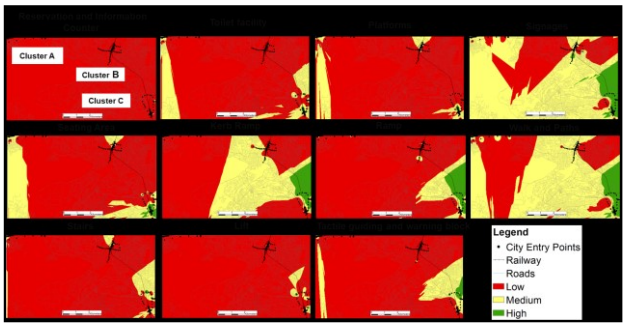

Figure 4. Eleven thematic raster maps based on universal accessibility parameters for City Entry Points

Fig 5 shows the universal accessibility status of public realm points in ten accessibility parameters. Sites in the newer part of the city such as *Indira Gandhi Rashtrya Manav Sanghralaya* (IGMRS), Tribal Museum and Regional Science Centre scored high in most parameters (8). Heritage precincts in the old city scored low in all ten accessibility parameters (fig.5). Among hotels, old hotels scored high only in one parameter i.e. Sidewalk and Footpaths. The newly built hotel scores high in most parameters which are also located in the newer part of the city.

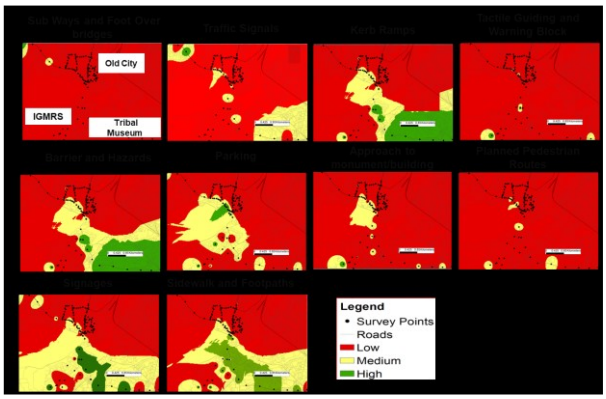

Figure 5. Ten thematic raster maps based on universal accessibility parameters for Public Realm

5.4. Weighted Overlay analysis in GIS

Overlay analysis tools in GIS provide the capability to assign weights to various input layers, amalgamating them into a unified output. Multiple approaches exist for conducting overlay analysis, each differing in methodology but adhering to the same fundamental steps for addressing multicriteria problems. In this research, the *Weighted Sum* tool was utilized, which overlays multiple thematic maps in raster data format, multiplies each by its assigned weight, and then sums them to generate an output raster (ArcGIS Desktop Help).

The classified maps displaying high, medium, and low accessibility zones were subsequently incorporated into the Weighted Sum tool. Weights were allocated to each accessibility parameter layer according to expert and stakeholder opinions. Expert opinions were gathered by consulting academicians specializing in disability studies from reputed national and international institutions. Stakeholders were reached through these experts. Both experts and Stakeholders were given the checklists for both 'Public Realm' and 'City Entry Points' and asked to put weightage to parameters in terms of most important to least important in the scale of 10-1 for 'Public Realm' and 11-1 for 'City Entry

Points’ since there are 10 and 11 parameters in ‘Public Realm’ and ‘City Entry Points’ checklists respectively. After receiving the score from both expert and stakeholders, the ‘Mean’ is calculated and mean values were used as weightages to parameters. For example, For City Entry Points, Platforms received the highest weight of 11, while ‘Stairs’ were assigned the lowest weight of 1.

Each raster layer was multiplied by its respective weight using the Weighted Sum tool, and the results were then combined. The final output shows hierarchy for accessibility zones for ‘City Entry Points’(fig.6) and ‘Public Realm’ (fig.7 A & B) encompassing identified tourist network within Bhopal city. Among city entry point clusters (section 3.1), Rani Kamlapati Railway Station and ISBT of cluster C (fig. 6) falls within the high accessibility zone. While there is a very high score in parameters like Signages, Walks and paths, Tactile Guiding & warning blocks, Walks and paths, Seating Area made Rani Kamlapati Railway Station very accessible; ISBT is highly accessible due to high score in parameters like Toilet facility, Signages, Seating Area, Stairs, Reservation and Information counters.

Figure 6. Weighted overlay maps accompanied with related images displays the sites of City Entry Points in different accessibility zones

Though Rani Kamlapati railway station is highly accessible, there is a scope for improvement as platform no. 1, 4, 5 score zero in parameters like Reservation and information counters, Kerb ramps. A Kerb Ramp not only enables easier access to sidewalks for visitors with locomotor disabilities, such as those using wheelchairs or crutches, but also enhances their safety by keeping them separated from busy streets. The lack of Kerb ramp can lead to the feeling of insecurity among these individuals. Access to Reservation and Information counter is necessary to start a journey. By improving the accessibility of cluster C, the city will be able to attract more people with disabilities.

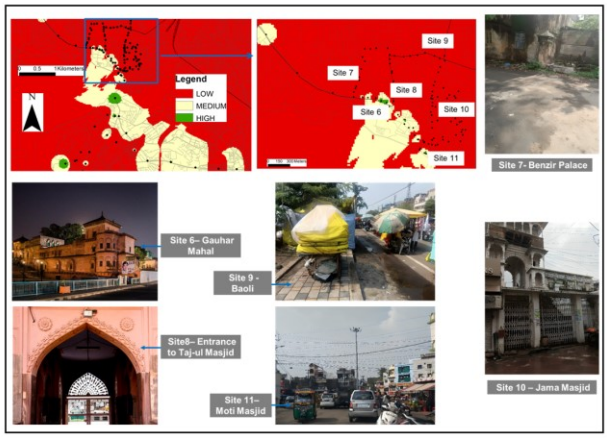

Figure 7. A. Weighted overlay maps accompanied with realted images displays the sites of Public realm Points in different accessibility zones (older part of Bhopal city is zoomed in)

Figure 7A shows hierarchy of accessible zones in the categories of high, medium, and low along the roads from city entry points to accommodation points and those near heritage sites in the older part of Bhopal City. Figure 7A shows that within old city, *Taj-ul Masjid* (site 8), *Gauhar Mahal* (Site 6), are falling within high accessibility zone. These sites are located along the heritage walk proposed by BDP 2031. Detailed investigation reveals that high scores in parameters like Traffic Signals, Kerb Ramps, Signages, Sidewalks and Footpaths contributed to the high accessibility status.

Figure 7 B. Weighted overlay maps accompanied with related images displays the sites of Public Realm Points in different accessibility zones (newer part of Bhopal city is zoomed in)

In the new city part, Road to Jehan Numa Palace (site 4), Road to Palash Residency (site 5), *Indira Gandhi Rashtrya Manav Sanghralaya* or IGMRS (Site1) and Hotel *Shri Vinayak Palace* (Site 12) are falling within high accessible zone (fig.7B). Detailed investigation reveals that high scores in parameters such as Tactile Guiding and Warning blocks, Barriers and Hazards contributed to the high accessibility status in these sites. *IGMRS* is the major tourist attraction in Bhopal. Hotel *Jehan Numa Palace* is the heritage structure thus one of the most visited sites. High scores in accessibility parameters will enhance accessible tourism potential of Bhopal city. Improvements can be made in parameters like Traffic Signals at IGMRS (site 1) as it scored zero in that parameter. Receiving a zero score in Traffic Signals indicates the absence of pedestrian traffic lights or the inadequate programming of the time

interval for crossing, which fails to accommodate the pace of the slowest individuals crossing the road. Road to *Tribal Museum* (site 2) and Regional Science Centre (site 3) falls under the zone of low accessibility. This is because site 2 score zero in almost all parameters except Parking Space, Signages, and Transport Heritage Interface. Site 3 scores zero in every parameter except traffic signal.

6.Proposal for Improving Universal Accessibility

The GIS analysis above identifies zones where physical infrastructure needs to be improved to enhance universal accessibility of the built environment. Further process involves identifying the intervention needed for improvement in physical accessibility. For that purpose, a categorization-based framework has been developed.

6.1. Framework for Proposal

The proposal of this research is focused on the categorization of each parameter concerning the city entry and public realm precincts with the least accessibility percentage. The proposal has been categorized into 4 types (table 3). The 4 categories are *Build, Retrofit, Maintenance*, and *Operation*. The 4 categorizations, their abbreviations, and their accessibility percentage range have been listed in Table 3. While **'Build'** means the spaces to be installed with features and equipment, from scratch to make the space accessible for users, '**Retrofit'** category implies that the space needs to install features to the existing condition for making it more accessible. The '**Operation'** category means the space to operate specific features, which are existing, to make the space smoothly functional for all types of user groups. In **'Maintenance'** category, not many changes are required concerning the space but needs maintenance of the existing situation to make it fully functional. Any accessibility parameter will be assigned to a particular category based on its accessibility percentage. For example, Reservation and information counters, Toilet facility *at Halalpura Bus stand* fall under 'Build' category as they score below 25%. It means to make the precinct accessible; accessibility features need to be installed from scratch.

Table 3. Abbreviations and ranges of proposal categories.

Abbreviation	Categorization	Range of Accessibility percentage
B	**Build**	0-<25
R	**Retrofit**	26-≤50
O	**Operation**	51-≤75
M	**Maintenance**	76-≤100

6.2. Accessibility proposal for City Entry Points

Table 4. Proposal categorization of each accessible parameter concerning City Entry points.

	Reservation and information counters	Toilet facility	Platforms (alighting and boarding buses)	Signages	Seating Area	Kerb ramps	Ramps	Walks and paths	Stairs	Lifts	Tactile Guiding & warning blocks
Halalpura Bus Stand Precinct	3.8	3.4	0.0	35.1	9.4	1.0	9.4	31.5	0.0	0.0	3.1
Categorization											
ISBT	30	43	12.5	81	37.5	48	48	72	45	25	56.5
Categorization											
Approach to ISBT	0.0	15.5	0.0	51.1	17.6	51.9	50.2	48.5	21.2	23.5	36.5
Categorization											
Nadra Bus Stand Precinct	0.0	2.5	0.0	34.4	0.0	38.7	15.4	41.2	0.0	0.0	11.3
Categorization											
Bairagarh Railway Station Precinct	5.0	37.1	40.8	45.5	43.8	6.6	18.8	31.6	20.4	1.0	24.5
Categorization											
Bhopal Junction	11.7	14.	54.7	52.9	42.5	18.	22.0	55.5	35.0	17.	10.1
Categorization											
RKM	6.0	47.	49.5	75.0	76.9	26.	41.7	69.9	35.3	51	25.7
Categorization											

LEGEND: Build | Retrofit | Operation | Maintance

The parameters which need to build from scratch at maximum City Entry Points are **'Reservation and information** counters' and **'Lifts.'** The second highest are Toilet facility, Platforms (for alighting and boarding buses), Ramps, Tactile Guiding & warning blocks. Seating Area needs to be built from scratch in 3 sites (Harapura Bus station, Approach to ISBT, Nadra Bus stand). To make the 'Seating Area' accessible some retrofitting is needed at ISBT, Bairagarh Railway Station and Bhopal Railway station. A proper platform for alighting and boarding buses is missing in all bus stations and needs to be built from scratch.

6.3. Accessibility proposal for Public Realm Points

Table 5. Proposal categorization of each accessible parameter concerning Public Realm Points

	Sub Ways and Foot Over bridges	Traffic Signals	Kerb Ramps	Tactile guiding & warning blocks	Barriers and Hazards	Parking Space	Transport heritage interface/ approach to building	Planned Pedestrian Routes	Signages	Sidewalks and footpaths
Site 1 IGMRS	0.0	0.0	83.0	81.0	86.0	58.0	59.0	40.0	75.0	63.0
Categorization										
Site 2 Tribal Museum	0	0	0.0	0	0.0	10	6	0	0	0
Categorization										
Site 3 Regional SC Centre	0.0	0	0.0	0.0	0.0	23	21.0	0.0	10.0	0
Categorization										
Site 4 Jehan Numa	0.0	0.0	0.0	0.0	26.0	28.7	2.0	6.7	48.0	27.3
Categorization										
Site 5 Palash Residency	0.0	45	45.0	0.0	0.0	55.0	26.0	60.0	61.0	76.0
Categorization										
Site 6 Gauhar Mahal	0.0	67.	33.0	19.0	36.0	65.	47.0	20.0	77.0	89.
Categorization										
Site 7 Benzir Palace	0.0	0.	33.0	0.0	0.0	23.	24.0	0.0	0.0	0
Categorization										
Site 8 Taj Ul Masjid Precinct	4.3	44.7	61	29	45.3	49.3	44	33.3	52	54.3
Categorization										
Site 9 Road to Basti	0	0	0	0	0	0	6	0	0	38
Categorization										
Site10 Road to Jama Masjid	0	0	0	0	0	0	0	0	0	13
Categorization										
Site 11 Road to Moti Masjid	0	0	0	0	29	0	0	0	0	0
Categorization										
Site 12 Road front of Hotel Vinayak Palace	0	67	100	19	29	38	12	40	48	63
Categorization										

LEGEND: Build | Retrofit | Operation | Maintance

Among parameters, **'Sub Ways and Foot Over Bridges'** need to be built from scratch at maximum public realm sites (table 5). A few sites such as, IGRMS (site 1) Tribal Museum (Table 5) vehicular traffic is less so may not need the Sub Ways and Foot Over bridges. On the other hand, sites 6,7,10,11 which are located at core city require the Sub Ways and Foot Over bridges where both pedestrian and vehicular traffic are high. The second highest are Traffic Signals, Tactile Guiding & Warning Blocks. Transport Heritage Interface and Planned Pedestrian Routes are the third highest parameters which need to be built from scratch.

6.3. Conclusion of proposal

Comparison between table 3 and table 4 shows that accessibility parameters are in better condition at Public Realm precincts compared to City Entry precincts as frequency of parameters under Operation and Maintenance category are more in Public Realm precincts. This leads to the conclusion that City Entry points of Bhopal need more attention than public realm to make Bhopal accessible.

7. Conclusion and Wider Implications

Accessibility is realized when individuals with specific mobility, visual, auditory, or cognitive requirements can navigate and utilize the built environment with minimal need for adaptation. This study aims to introduce an integrated geospatial approach, merging statistics and cartography to enhance universal accessibility at Bhopal city. To evaluate the universal accessibility status of Bhopal city, Madhya Pradesh, India, access audit checklists were developed for City Entry Points and Public Realms. Using the checklists, physical survey was conducted along identified road sections of Bhopal city. The audit results were examined and presented using cartographic techniques provided by GIS. The analysis produced maps depicting the hierarchy of accessible zones, ranging from high to low. These maps identify the sites within tourist network that perform well in universal accessibility assessments compared to others. Detailed investigation reveals that site falling within a high accessible zone may still lack universal access parameters. Drawing from the multilevel approach to disability, an attempt has been made to explore the impact of missing built environments on the psychology of tourist with disabilities. Proposals have been developed according to whether a specific parameter requires New Construction or Retrofitting or Operation or Maintenance based on the relative percentage of each parameter at each site. The proposals for accessibility infrastructure development highlight that most of the parameters in both City Entry Points and Public Realm must be built from scratch, but City Entry Points need more attention than Public Realm.

Improvement in physical infrastructure alone cannot make Bhopal city accessible. Awareness of the requirements of persons with disabilities needs to be generated among city level service providers. While this research analysed the role of spatial parameters to improve universal accessibility of Bhopal city further research can be done on analysing non-spatial parameters.

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