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A FRAMEWORK FOR THE EMPIRICAL ASSESSMENT OF SOCIAL INTERACTION AND PLACE ATTACHMENT IN URBAN OPEN SPACES: EVIDENCE FROM NAGPUR, INDIA

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INTRODUCTION

Urban open spaces (UOS) are publicly accessible open places designed and built for human activity and enjoyment (Francis, 2003). Jan Gehl (1987) noted that modern cities are more diverse. There is a need for UOS to accommodate numerous everyday activities. UOS create an environment where people of different genders, ages, and incomes can meet and contribute to community life and be connected to each other as well as to the space (Basa, 2018). These engagements are termed social interactions. They provide opportunities to bond with others, develop a sense of community, and escape from daily routines (Cattell et al., 2008). They can also catalyse a feeling of attachment to the place (Peters et al., 2010; Sen and Guchhait, 2023). An open space that is a pleasure to inhabit becomes a symbol of civic pride (Faroldi, 2020). As people use UOS, they begin to gather experiences through their encounters with the space and the people they meet there. These encounters cause users to ascribe experiential value to the space, increasing place attachment. Social interaction and place attachment in UOS are important to the notion of community (Ojalammi and Koskinen-Koivisto, 2024).

While the environmental and economic benefits of UOS are widely addressed (Badar and Bahadure, 2025; Das et al., 2022; Junior et al., 2022; Swain and Bahadure, 2025) research on their social advantages remains limited. Most existing studies focus on health benefits (Reyes-Riveros et al., 2021; Wang et al., 2019); ecosystem services at the household and city level (Ring et al., 2021; Wang and Foley, 2021); and accessibility (Kamble and Bahadure, 2021; Punglia and Bahadure, 2021; Shi et al., 2020). The few studies that directly assess social interaction (Aram et al., 2019; Peters et al., 2010) and place attachment (Sen and Guchhait, 2023) focus on selected planned UOS at the neighbourhood level. Evaluations based on user perceptions (Ahirrao and Khan, 2021) offer important insights for researchers. However, they often lack practical utility for planners because

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they do not adequately connect perceptions to physical, managerial, or provisioning aspects of UOS.

Rapid urbanisation and the expansion of cities have resulted in a loss of UOS to make way for built structures and transport infrastructure (Sangwan et al., 2022). In India, most major cities have low open space per capita ratios (Khan, 2014). The available UOS are unable to meet the needs of the diverse population due to a lack of guidelines, limited funding, the absence of public participation (Ahirrao and Khan, 2021), and conflicting preferences that the institutions are unable to account for (Kronenberg et al., 2023). Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines (MoUD, 2014) provide recommendations for the categorisation, quantity, and accessibility of UOS. However, these guidelines are limited to formally planned spaces, including neighbourhood parks and playgrounds, community parks, district-level parks and sports centres, city-level parks and sports complexes, and city botanical/zoological gardens. These spaces are institutionally planned and governed, but other UOS emerge through local initiatives to accommodate incidental activities (Stanley et al., 2012). These are either semi-planned, providing an overall structure but flexible use, or unplanned, which come into use through appropriation by the people (Aral et al., 2022). These spaces remain unaccounted for, and their potential to nurture social interaction and place attachment is not included during the planning process.

While the size, function, management, and type of land cover of open spaces are documented, further research is required that relates these characteristics to the ways UOS are used and the experiential values users attach to them (Ives et al., 2017). Addressing this gap is essential in creating more convivial spaces. It is recognised that UOS can not be described only by i) physical attributes and ii) user activity patterns, but also by iii) planning and management, and iv) experiential values attached to them due to user experience. The study aims to develop and empirically test an assessment framework that evaluates social interaction and place attachment in UOS across these four aspects. This framework applies to various types of UOS and different spatial scales. It tests two hypotheses: i) H1: Social interaction and place attachment are influenced by the physical attributes of the UOS; and ii) H2: Social interaction and place attachment are affected by the level of control over the planning and use of the UOS. By applying this framework to UOS in Nagpur, India, at both city and neighbourhood levels, the study seeks to provide actionable insights for urban planners and policymakers to better integrate social factors into UOS planning and management.

The remaining sections of the paper are structured as follows. Literature Review and Framework Development reviews the literature on social interaction and place attachment. It links these concepts to the physical attributes, and the planning and management of UOS by developing an assessment framework. The framework is applied to investigate the UOS in Nagpur (India), using data collected on planned, semi-planned, and unplanned spaces, first at the city level and then in a selected neighbourhood. The two hypotheses are tested statistically, examining the relationship between social factors and the physical attributes, as well as their variations across different categories of open space. Results discusses the outcomes of the study, and the conclusions are drawn regarding the physical requirements and the contributions of different UOS to social interaction and place attachment.

LITERATURE REVIEW AND FRAMEWORK DEVELOPMENT

Understanding Social Interaction and Place Attachment in UOS

Social interaction is the relationship between two or more people that tends to generate a mutual reaction between them (Shafique et al., 2020). UOS play a pivotal role in encouraging interactions. They provide accessible environments where people from diverse social and economic backgrounds can meet, observe, and engage in daily activities (Bakker and Ritts, 2018; Elfartasa et al., 2022; Mansournia et al., 2021). Users can also experience others functioning in various situations. Planned UOS recommended by URDPFI Guideline (MoUD, 2014) allow both social ties, community networks, and a sense of belonging. The opportunity to interact is essential for human life (Kapoor & Putta, 2016) and offers relief from the daily routine (Chen et al., 2024; Olszewska-Guizzo et al., 2022).

Place attachment is the affective bond between people and places (Bottini, 2023). This bond is influenced by a complex equation of physical attributes, accessibility, social interactions, and cultural context. People value a space more if it meets their needs and provides opportunities for different activities (Al-Mendilawi and Al-Saaidy, 2024). When these activity spaces are inclusive in their accessibility, they resonate with diverse community backgrounds (Ghasemieshkaftaki et al., 2023). By using UOS through individual and social activities, users form connections to the place and the people who simultaneously occupy it (Kearns and Forrest, 2000). Repeated experiences over time foster a sense of continuity, making the space feel familiar and safe. However, in some cases, the experiences may be unpleasant and form negative associations (Weijs-Perrée et al., 2020). A space becomes a place when it acquires significance through processes, memories, symbols, and experiences, which can be individual or collective (Sebastien, 2020). UOS often contain symbols: public art, monuments, and historic buildings that act as anchors for collective memory and identity, reinforcing the significance of a place for both individuals and communities (Low, 2022). While these deeper connections are central to place attachment, researchers recognise that values attached due to user experiences serve as practical proxies to enable systematic measurements (Jayakody et al., 2024).

Existing Frameworks and Indicators

Social interaction and place attachment are assessed through users' behaviour patterns or perceptions (Ghasemieshkaftaki et al., 2023; Shafique et al., 2020). When UOS are easily reachable and inclusive, they attract a broader demographic, thereby increasing the potential for diverse interactions (Peters et al., 2010). According to Sulyk (2023), the design and arrangement of UOS elements, such as seating, paths, and play areas, directly influence the frequency and quality of social interactions by stimulating connections among people. It can also determine the time and duration of visits, shaping the types of engagements that occur, from fleeting interactions to enduring relationships (Sulyk, 2023). Peters et al. (2010) state that UOS can facilitate social interaction by i) being accessible to a diverse population and ii) through the choice and arrangement of various elements that stimulate connections between people.

Previous research indicates that evaluating place attachment in UOS involves a multidimensional approach. It considers the affective bond and sense of belonging that users feel towards a space (Zamanifard et al., 2019), as well as users' perceived sense of the safety (Türkseven Doğrusoy Zengel, 2017), comfort, and pleasure derived from the space, and the emotional or symbolic meanings attached (Low, 2022). These are together encompassed in i) the user experience as it reflects how users perceive, feel, and assign experiential value to the UOS during their visits. According to Ujang and Maulan (2018), place attachment is also influenced by ii) the frequency of engagement with the space.

The review of literature indicates that few assessment methods combine the multiple aspects of UOS to examine empirically how they influence the social interaction and place attachment. The present study addresses this gap across planned, semi-planned, and unplanned spaces, at both city and neighbourhood levels.

Development of Multidimensional Assessment Framework

To test the proposed hypothesis, it is essential to connect social interaction and place attachment to the physical attributes, spatial characteristics, planning, and management of UOS. The two social factors are complex constructs that rely on more than one aspect of UOS. Previous studies focus on one or two aspects, often emphasising physical attributes or user perceptions (Holland et al., 2007). The present study considers a comprehensive multidimensional assessment framework for social interaction and place attachment in UOS.

Four aspects characterise UOS: i) the planning and management carried out by planners and regulators, ii) the physical attributes that describe the spatial morphology, iii) the user activity patterns shaped by the organisation, accessibility, and use of the activity areas, and iv) the experiential values that reflect the social meanings attributed by users through their experiences (Wan et al., 2021). The parameters describing these attributes are identified from previous studies (Alvares and Barbosa, 2018; Badar and Bahadure, 2020; Carmona, 2019) to develop a framework.

Planning and Management

Research shows that the concept and design of the UOS, created by designers and planners, as well as the rules, policies, and management practices, govern how, when, and by whom the space can be utilized (Moroni and Giuseppe Lorini, 2016; Randrup et al., 2021). This aspect of UOS is shaped by representations such as zoning maps, planning documents, and policies.

Physical Attributes

The physical characteristics of UOS can be directly observed, measured, and mapped (Poplin et al., 2020). They are the material aspects of the environment, such as its size and geometry, level of openness, amount and type of greenery, and spatial relationship with the surrounding built environment.

User Activity Pattern

This aspect describes when, how often, and how people use the UOS. User behaviour within the open space is influenced by its spatial characteristics (CABE, 2013) like accessibility, and the amenities provided, their quality and distribution.

Experiential Values

This UOS aspect refers to the non-physical, experiential, and emotional qualities that users ascribe to an open space (Ives, 2015; Lopes et al., 2015). These are subjective perceptions that arise from people's interactions and experiences associated with the space and are also dependent on the time spent in the UOS.

Indicator Selection and Description

Planning and management of a UOS is understood by the level of control exercised over its planning and use. UOS designated in the City Development Plan (CDP), provided with defined boundaries, and maintained for their intended recreational purpose, are categorised as planned. The UOS that are indicated in the CDP but allow more flexible entry, use, and adaptation beyond their original intent are termed semi-planned. In contrast, spaces not identified in the CDP but informally appropriated by residents for recreation and social interaction are labelled as unplanned. The distinction depends on the rules and regulations imposed on the space, either through signage or oral communication.

A previous study by Lopes et al. (2015) is referenced to define the physical attributes of UOS and the indicators of their morphology: i) void shape; ii) permeability; iii) urban density; and iv) land use, followed by the user activity patterns: v) spatial organisation; vi) accessibility; and vii) user activity. Criteria and indicators are listed in **Table 1**. Void shape considers the UOS as voids within the built environment and employs indicators to define the physical characteristics of the spaces. The entropy of symmetry describes the deviation from the shape symmetry of the open space. The greater the entropy, the more unsymmetrical the shape. Lopes et al. (2015) describe permeability as the nature of the connection between the UOS perimeter and the surrounding environment as an interface between the public and private realms. Urban density relates the area of the UOS to that of the surrounding built area. The entropy of land use determines the mix of different land uses adjacent to the UOS. Land use also considers the green surface cover and the amount of shading provided within the UOS.

User activity pattern maps the spatial organisation of the UOS, which is the arrangement of activity areas and the quantification of their area. Accessibility, as a relative nearness of one place to another, indicates ease of reaching a destination from an origin (Abubakar and Aina, 2006). This is an important factor that determines the use of the UOS (Halecki et al., 2023). Two values are used to indicate accessibility: i) connectivity, which refers to the directness of links and density of connections (i.e., intersections) in street networks (Mecredy et al., 2011); and ii) integration, which is a function of the mean depth (number of connections that must be traversed) if one were to move from every space (node) to every other space (node) (Koohsari et al., 2014). User activity is determined by i) the frequency of users coming to the UOS, ii) their distribution within the open space, and iii) the time they spend per visit.

Experiential values are identified under Jan Gehl's (1987) three quality criteria for good public space: i) protection (P) - makes people feel safe and secure; ii) comfort (C) - provides an environment conducive to staying, interacting, and experiencing psychological well-being; and iii) enjoyment (E) - creates opportunities for sensory pleasure, aesthetic experience, and positive encounters (Badar and Bahadure, 2020). A list of twelve experiential values present in UOS is identified from previous literature

(Chiesura, 2004; Schipperijn et al., 2010; Tyrväinen et al., 2007): i) P- safety, natural beauty, and climate; ii) C- accessible, recreational opportunity, physical health, social ties, economic opportunity, and psychological well-being; and iii) E- aesthetic enjoyment, creative use, and religion/culture (**Figure 1**).

Conceptual Framework

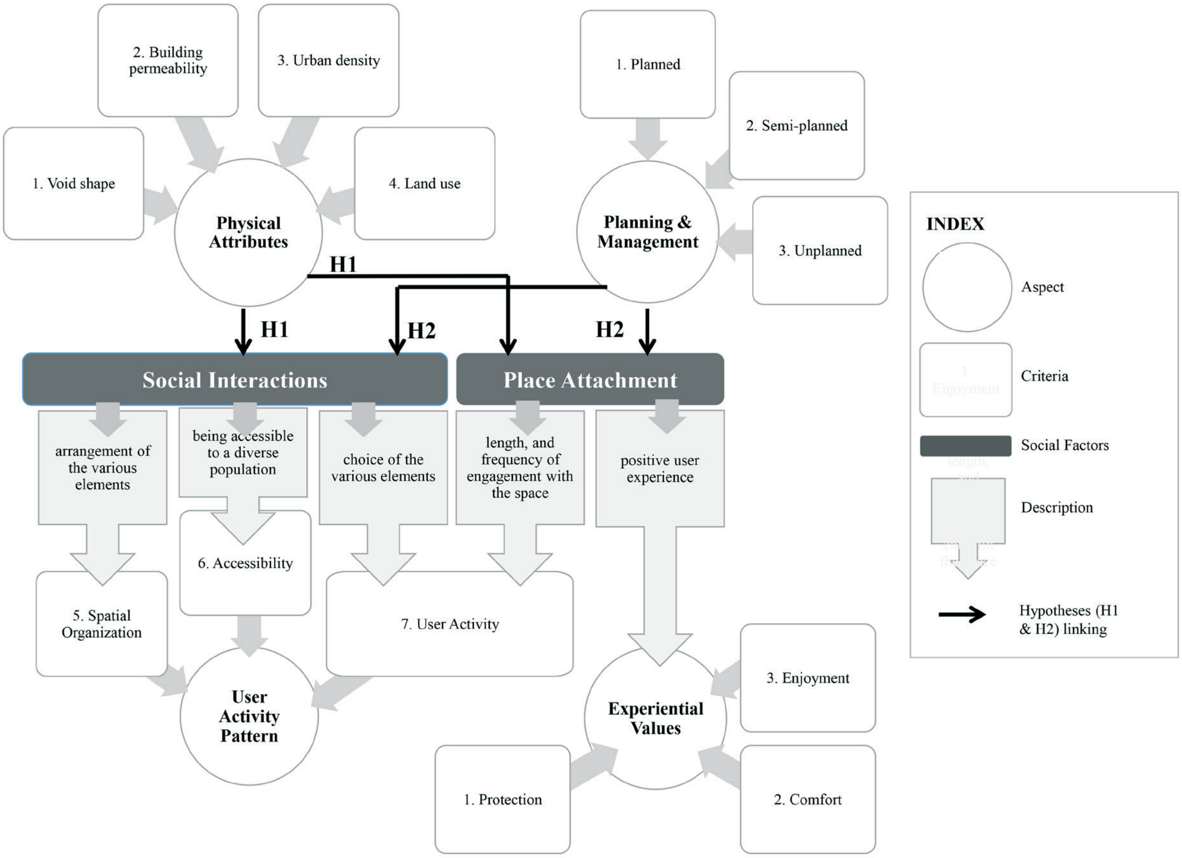
The four aspects of UOS (planning and management, physical attributes, user activity patterns, and experiential values) are integrated to assess their combined influence on social interaction and place attachment, as illustrated in **Figure 1**. The conceptual model hypothesises that both the physical attributes and the level of planning and management together influence social interaction and place attachment in UOS.

RESEARCH DESIGN AND METHODS

Measurement Methods

The framework has twelve criteria with identified indicators (**Table 1**). Methods of data collection and analysis are devised for these at the city and neighbourhood levels.

Figure 1. The conceptual model showing the connection between the four aspects of UOS, social interaction, and place attachment. It also indicates the hypotheses testing.



Planning and Management

City level: The data on the planning measures and regulations is collected from city development plans and other government planning documents. The CDP provides the location of planned open spaces.

Neighbourhood level: Informal interviews with users and management staff at individual UOS are carried out to understand the rules and regulations on the use of each UOS. This aspect is considered static for the purposes of the present study.

Table 1. Framework of criteria and indicators for the four aspects of UOS, with their unit of measurement, data collection methods, and their connection to the different factors.

Aspect	Criteira		Indicators	Unit	Data Collection
Planning & Management	1. Concepts 2. Codes		Planned Semiplanned Unplanned		Landscape plans, Planning Documents, Rules & Regulations
Physical Attributes	3. Void Shape	i	Area	Sqm.	ArcGIS & AutoCAD
		ii	Perimeter	m	
		iii	Aspect Ratio	Ratio	
		iv	Entropy (Symmetry)	bits	
	4. Building Permeability	v	Perimeter/Entrances	Ratio	ArcGIS & Google SketchUp
		vi	Opening density	Nos./ sqm	
	5. Urban Density	vii	UOS area/Adjacent building footprint area	Ratio	ArcGIS
	6. Land use	viii	Entropy of adjacent land use	bits	ArcGIS
		ix	Green landcover	Ratio	Google SketchUp
		x	Shading	Ratio	
User Activity Pattern	7. Spatial Organisation	xi	Activity Areas	Ratio	ArcGIS
	8. Accessibility	xii	Travel Time	hrs	User Survey
		xiii	Connectivity	-	Depth Map
		xiv	Interaction		
	9. User Activity	xv	Spatial Distribution of Users	Persons	SOPARC
		xvi	Frequency of Use	Visits/ week	User Survey
		xvii	Time Spent	hrs	
Experiential Values	10. Protection	a.	Safety	Likert scale	User Survey
		b.	Natural Beauty	1-very low	
		c.	Climate	2- low	
	11. Comfort	d.	Accessible	3- moderate	User Survey
		e.	Recreational Opportunity	4- high	
		f.	Physical Health	5- very high	
		g.	Social Ties		
		h.	Economic Opportunity		
		i.	Psychological Well Being		
	12. Enjoyment	j.	Aesthetic Enjoyment		User Survey
		k.	Creative Use		
		l.	Religion/Culture		

Physical Attributes

City level: Selected indicators give a broader picture of the physical attributes at this level. They are defined by their void shape, derived from GIS mapping. The URDPFI Guidelines categorise the UOS into hierarchical levels according to their size, amenities, and population served. This study further groups them into 1. Lower Level (Neighbourhood and housing area levels) and 2. Higher Level (Community, sub-city, city, and district levels) to represent their physical attributes.

Neighbourhood level: The physical characteristics are studied in detail through the indicators in the framework. The measures of area and perimeter are extracted from GIS mapping and used to calculate the aspect ratio (Equation 1). The entropy of symmetry is determined by box counting as explained in **Figure 2**. A window (ABCD) is created around each UOS with its maximum dimensions. Within this window, the green boxes (with more than 75% green) denote the area under open space. The grey boxes (with more than 75% grey) represent other land uses, including built areas. The entropy is calculated by Equation 2. Building permeability is determined by the UOS perimeter geometry and its interface with the abutting building facades (Equations 3 and 4). Urban density relates the area of the UOS to the built-up footprints of the adjacent building blocks in Equation 5. The entropy of the surrounding land use is calculated using Equation 6. The green surface cover within the UOS is calculated as a ratio of the total UOS area using Equation 7. Shading is derived from models created in Google SketchUp by geolocating the neighbourhood, and considers the sun location during the hottest month of May. Similar to green cover, the shaded area is also considered as a ratio to the total UOS area (Equation 8).

The equations for indicators of physical attributes are given below:

$$Aspect\ Ratio = \frac{Area\ of\ UOS}{Perimeter\ of\ UOS} \quad \text{(Equation 1)}$$

$$Entropy\ of\ symmetry = -\sum_{i=1}^{k} P(box_i).\log_2\big(P(box_i)\big) \quad \text{(Equation 2)}$$

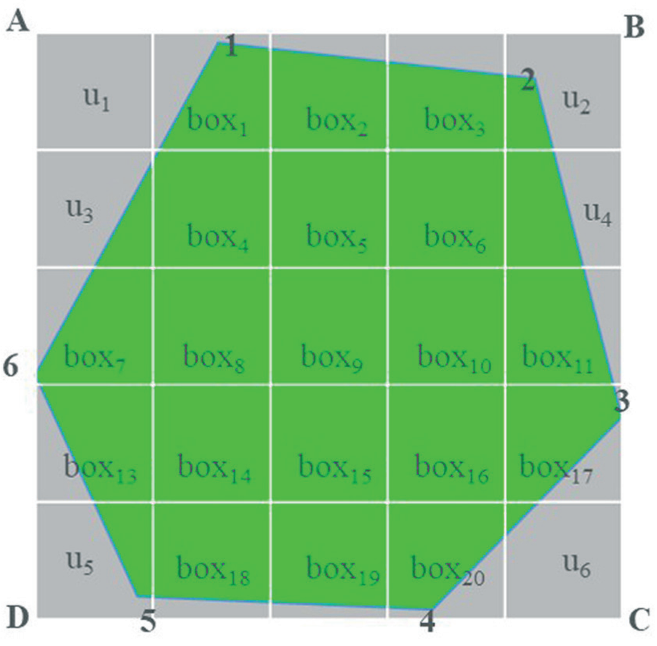


Figure 2. Illustration of box counting, where the green boxes labelled box_i are UOS and the grey boxes labelled u_i represent other land uses.

where P(boxi) is the probability of the ith box being positive (UOS) when randomly selecting one from the set of boxes that make up the UOS.

$$Permeability = \frac{Perimeter\ of\ UOS}{Length\ of\ surrounding\ building\ frontage} \quad \text{(Equation 3)}$$

$$Opening\ Density = \frac{Number\ of\ Openings\ overlooking\ UOS}{Length\ of\ surrounding\ Building\ frontage} \quad \text{(Equation 4)}$$

$$Urban\ Footprint\ Density = \frac{area\ of\ the\ UOS}{adjacent\ building\ footprint\ area} \quad \text{(Equation 5)}$$

$$Entropy\ of\ adjacent\ land\ use = -\sum_{i=1}^{k} P(u_i).\ log_2\big(P(u_i)\big) \quad \text{(Equation 6)}$$

where P(ui) is the probability of the ith land use when randomly selecting one from the set of land uses that surround a UOS.

$$Green\ Cover = \frac{Area\ of\ UOS\ under\ green\ cover}{Total\ area\ of\ UOS} \quad \text{(Equation 7)}$$

$$Shading = \frac{Area\ of\ UOS\ under\ shading\ in\ May}{Total\ area\ of\ UOS} \quad \text{(Equation 8)}$$

User Activity Pattern

City level: To collect data on user activity patterns, a city-wide questionnaire survey is implemented online, asking participants the frequency of use of the mentioned UOS, categorised as daily, 4-6 times a week, 1-3 times a week, 1-3 times a month, 1-3 times a year, or never.

Neighbourhood level: The types of activities and their locations within the UOS are recorded during on-site observations. These areas are categorised into green (lawns, tree patches, and farms), green/grey (miscellaneous areas), and grey areas (stage, play and exercise zones, and walking track), and are mapped using QGIS to analyse their spatial layout. The ratio of green and green/grey areas to the grey areas provides an overview of the spatial organisation of activity zones, as outlined in Equation 9. Data on user activity is collected by observing the number of users in each activity area within each UOS. Observations are conducted from two vantage points within each UOS. These observations occur during four fifteen-minute intervals, both in the morning (6:00–9:00 am) and in the evening (5:00–8:00 pm), on weekdays and Sundays. A ratio of the number of people in green and green/grey areas to those in grey areas is calculated to serve as an index of how people are distributed within the UOS (Equation 10). It is observed that the selected UOS are each predominantly used at different times of the day. A venue-based time-space sampling (TSS) frame is devised, drawing upon the methodology described by Muhib et al. (2001). The UOS constitute the locations within the TSS framework, and one-hour time intervals corresponding to key activity periods are identified for each UOS. The combination of location with a specific day and time interval forms a venue-day-time (VDT) unit, the primary sampling unit. Time intervals were chosen considering the observed differences in morning and evening user numbers and activities, and the intensity of use on the Sunday as compared to the weekdays. A structured questionnaire is used to interview people entering the UOS during each VDT. Information is gathered about the time it takes users to reach the UOS, the frequency of visits, and the average time spent on each visit. An index is framed to describe the behavioural pattern in terms of the frequency of visits to the UOS and the average time spent on each visit (Equation 11). An open-source software called DepthMap, developed by University College London (UCL), is used to analyze AutoCAD maps of the UOS and generate values for connectivity and integration as indicators of accessibility, which are combined into an index (Equation 12).

Equations for indicators of user activity patterns are given below:

$$Spatial\ Organization\ Index = \frac{Green\ Area + Green/Grey\ Area}{Grey\ Area}$$ Equation 9

$$Spatial\ Distribution\ Index = \frac{Percentage\ of\ Activity\ in\ (Green\ Area + Green/Grey\ Area)}{Percentage\ of\ Activity\ in\ Grey\ Area}$$ Equation 10

where Activity is the number of people observed using the activity area in fifteen minutes.

$$User\ Activity\ Index = Frequency\ of\ Visit * Time\ Spent$$ Equation 11

$$Accessibility\ Index = Travel\ Time * \frac{(Connectivity + Integration)}{2}$$ Equation 12

where Travel Time is measured in hours.

Experiential Values

City level: In the online survey, respondents are asked to rate the presence of the twelve experiential values within the UOS. The ranking is on a Likert scale from 1: very low to 5: very high.

Neighbourhood level: In a user survey of the UOS, the participants are asked to rank the indicators detailed in **Table 2** on a Likert scale from 1:very low to 5:very high. The data is averaged to measure the experiential values in each open space (Equations 13-15). A demographic profile of the users is generated through visual surveys and questionnaires.

$$Protection = \frac{1}{N_P} \sum_{i=1}^{N_P} P_i$$ Equation 13

$$Comfort = \frac{1}{N_C} \sum_{i=1}^{N_C} C_i$$ Equation 14

$$Enjoyment = \frac{1}{N_E} \sum_{i=1}^{N_E} E_i$$ Equation 15

The developed framework with four aspects, twelve criteria, and related indicators is used to gather and analyse data in a study of Nagpur (India) at the city and neighbourhood levels.

Study Area

Nagpur has an area of 225.08 sq.km and is divided into ten administrative zones. Forty-five percent of the land is under residential use, while land under planned UOS covers 8% of the city area, which is far below the 18-20% recommended by the URDPFI guidelines (MoUD, 2014). The Nagpur City Development Plan 2011, prepared in 1986, provides numerous small parks, with a majority less than two hectares in area. The parks

Indicator	Sub-indicator	Indicator	Sub-indicator
Protection		**Comfort**	
1. Safety	a.Provides a safe place for children to play	4. Accessible	a. Is within walking distance of the home
	b. Is safe to be after dark		b. Can be used by people with special needs
2. Natural Beauty	a. Allows experience of nature	5. Recreational Opportunity	a. Provides amenities for play
	b. Protects natural flora & fauna		b. Provides amenities to socialise
3. Climate	a. Provides shelter from sun/rain	6. Physical Health	a. Provides opportunity to live an active lifestyle
	b. Regulates the climate in the area		b. Allows engagement in sport/ activity
Enjoyment		7. Social Ties	a. Provides opportunity to interact with friends
10. Aesthetic Enjoyment	a. Is beautiful & well maintained		b. Provide an opportunity to enjoy with family
	b. Is not crowded/noisy	8. Economic Opportunity	a. Provides opportunity for earning a livelihood
11. Creative Use	a. Enhances the imagination and thinking		b. Increases land/ house prices
	b. Allows engagement in creative activity	9. Psychological Well Being	a. Is peaceful
12. Religion/ Culture	a. Is of religious/cultural importance		b. Provides opportunity to relax, sit / sleep
	b. Provide opportunity to hold r/c events		

Table 2. Twelve experiential values grouped under Protection (P), Comfort (C), and Enjoyment (E).

and playgrounds are planned and maintained by the Nagpur Municipal Corporation (NMC). The NMC Garden Department maintains 117 gardens across ten zones, and the Sports Department maintains 70 playgrounds, which form the planned UOS. In addition to these planned spaces, there are numerous unplanned UOS.

For the study at the city level, ten important and popular UOS are identified at different hierarchical levels in terms of size and planning. At the neighbourhood level, the NMC was consulted to choose Jagruti Nagar Garden and its surrounding UOS. Redeveloped under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the garden spans 1.17 hectares, though only 0.6 hectares are developed due to disputes and a community farm taking up the remaining area. A 400 m radius around the garden, refined by major roads and natural boundaries, forms the study area. An initial reconnaissance survey and informal intercept interviews assess social activity, leading to the identification of eight diverse open spaces: planned, semi-planned, and unplanned, allowing for comparison in the study.

The study is conducted at the city and neighbourhood levels, and the data is collected across the four aspects.

Data collection

Planning and Management

City level: An understanding of the city UOS planning is gained by referring to government planning documents, including the City Development Plan (MoUD, 2015a), and the Nagpur Smart City Proposal (MoUD, 2015b). The selected city-level open spaces are categorized according to their level of planning and management as i) planned UOS: 1) Satpuda (district garden); 2) Ambazari Garden (community garden); 3) Kasturchand Playground (community playground); 4) Traffic Park (community garden); and 5) Futala Lake Front (community garden); ii) semi-planned spaces: 6) Neighbourhood Garden and 7) Neighbourhood Playground as they usually provide more flexibility in use; and iii) unplanned spaces: 8) Food Stall/ Tapri; 9) Sitting Space; and 10) Street Market that provide informal meeting spaces (**Figure 3**). The lower-level (semi-planned and unplanned) UOS are spread across the city, and the survey participants are asked about the spaces that are closer to their residences. They are thus assumed to be generic in nature.

Neighbourhood level: The table in **Figure 4** shows the level of control for each of the eight UOS at the neighbourhood level. The Jagruti Garden landscape plans emphasise greenery and aesthetic appeal. The garden features a lawn and flower beds, which are maintained by a gardener. It features a well-designed children's play area, an exercise area for seniors, and a walking path. NMC limits its use in the evening, permitting only members of the karate club from 6:00 pm to 8:00 pm. K.T. Nagar Garden is larger and offers more activity zones. It remains open in the evenings, as does the K.T. Nagar playground. The community farm, run by a group of enthusiasts, welcomes visitors of all ages to explore the premises. Neem Park and the temple front provide fewer facilities but are less restrictive in their use. The vacant space is turned into an exhibition or community gathering area when needed. The street market is open to all and features flexible spots for people to gather, sit, and meet.

Physical Attributes

City level: GIS mapping is used to extract the void areas of each UOS. They are grouped into the lower-level and higher-level to represent their physical attributes.

Neighbourhood level: The study area, with its eight selected UOS, is mapped in QGIS and modelled in Google SketchUp and DepthMap. The data is processed using Equations 1-8 (Refer to Supplementary Table I).

User Activity Pattern

City level: Data about frequency of use of the ten selected UOS is collected from 315 randomly sampled city residents of varied ages (35% between 18 –24 years, 59% between 25 –64 years and 6% above 65 years), gender (57% female and 43% male), and income (6% lower, 74% middle, and 19% higher income group) in an online residents survey.

Neighbourhood level: A total of 26 VDT units are identified across the neighbourhood UOS, comprising the sampling frame. The sample of 417 user interviews includes a range of age groups (31% between 6-18 years, 37% between 18-59 years and 29% above 60 years), gender (56% male and 44% female), and income groups (44% lower, 44% middle, and 13% higher income). Data is collected from observations, user surveys, as seen in **Figure 5 a-d** and processed using Equations 9-12.

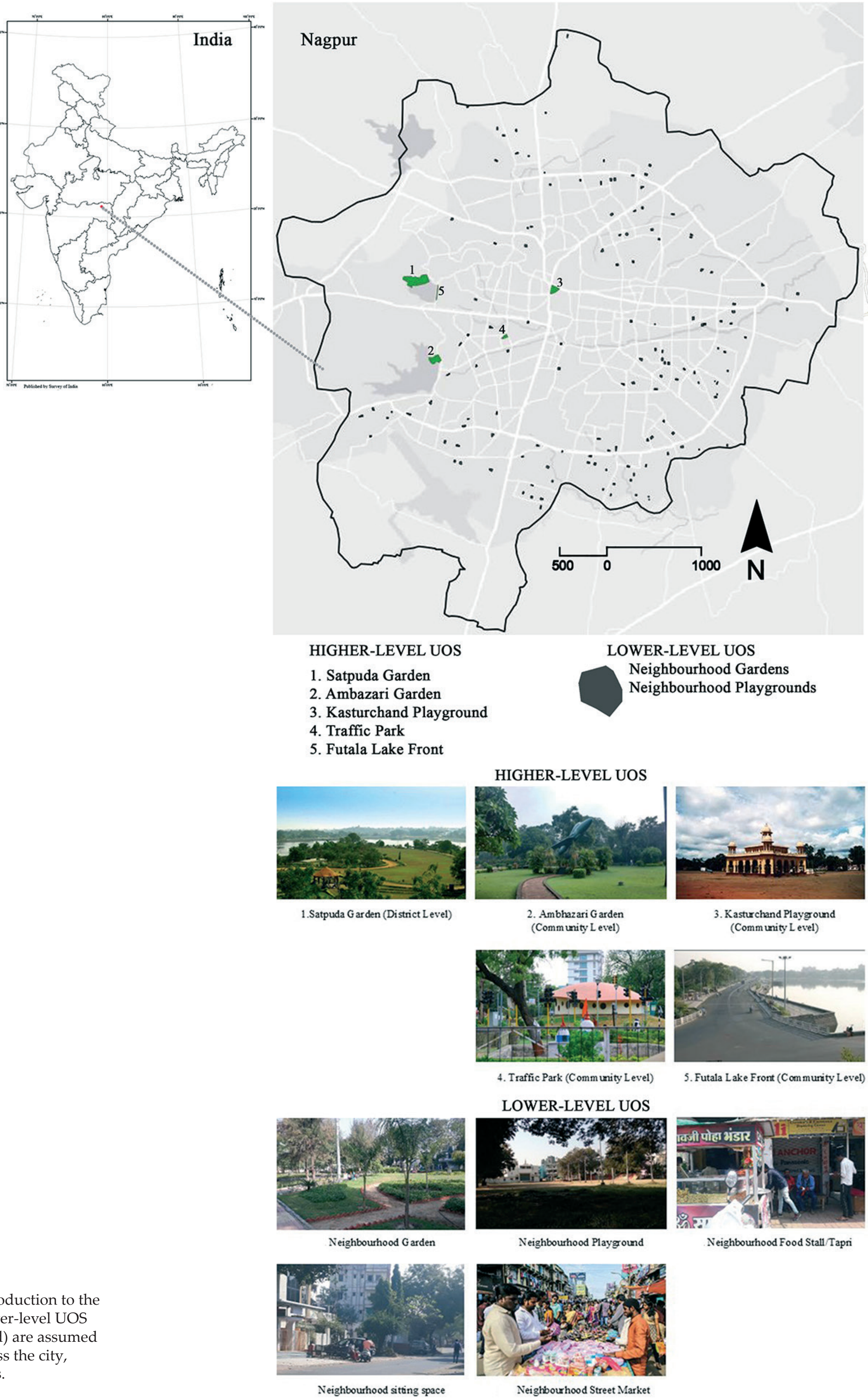
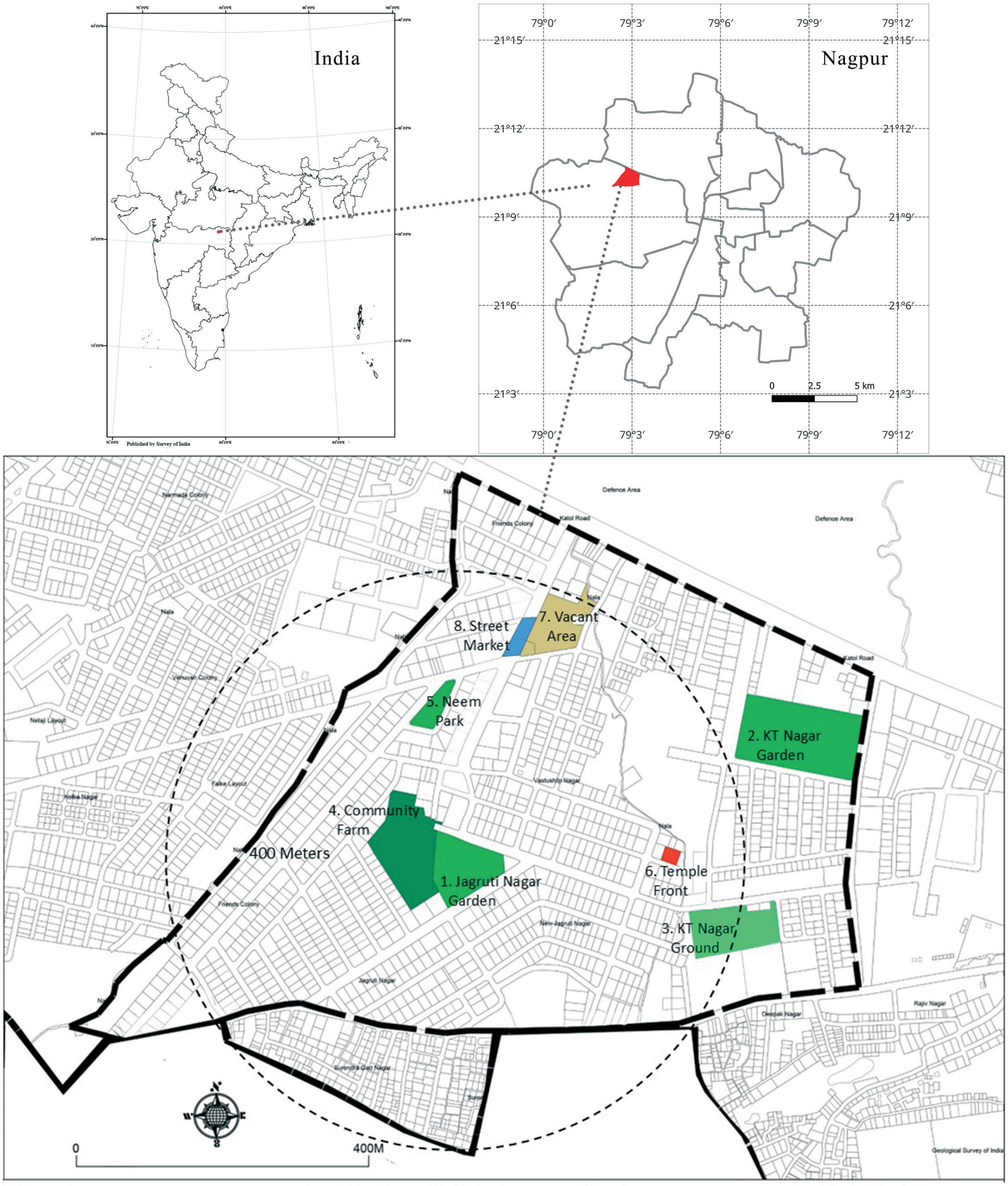


Figure 3. Map and visual introduction to the selected UOS in Nagpur. Lower-level UOS (semi-planned and unplanned) are assumed to be generic and spread across the city, present in all neighbourhoods.



SN	Name	Area (Ha)	Responsible Authority	Hierarchy	Level of Control
1	Jagruti Nagar Garden	0.64	NMC	Housing Area Park	Planned
2	KT Nagar Garden	1.37	NMC	Neighbourhood Park	Planned
3	KT Nagar Playground	0.80	NIT	Neighbourhood Playground	Planned
4	Community Farm	0.98	NMC/ Private		Semi-planned
5	Neem Park	0.32	NMC	Housing Area Park	Semi-planned
6	Temple front	0.01	NMC		Semi-planned
7	Vacant Area	0.68	Unknown		Unplanned
8	Street Market	0.05	NMC		Unplanned

Figure 4. Location and details of area, hierarchical level, and control of the selected UOS in a neighbourhood study area demarcated in a thick black dashed line.

Experiential Values

City level: Data on people's perception of experiential values is extracted from the online survey.

Neighbourhood level: The user survey provides data on users' perception of the presence of experiential values in the selected UOS (Refer to Supplementary Table II). The data is processed using Equations 13-15.

Measurement and Analysis

The planning and management at the city level reveal that the regulations help to preserve tree cover and promote the creation of UOS. Yet, when compared to the physical space, the area allocated to planned parks and playgrounds is found to be insufficient compared to the requirements specified in the URDPFI Guidelines, especially at the housing area level (**Figure 6**).

The collected data is statistically analysed in JASP Version 0.18.2, an open-source statistical tool developed by the University of Amsterdam and based on R, a language and environment for statistical computing and graphics (Shah, 2013). At the city level, user activity, measured as the product of the number of users and their frequency of visits, or the demographic diversity of the UOS users, is used as a proxy for social interaction. The user's perception of experiential values in UOS is considered a measure of place attachment.

H1: Social Interaction and Place Attachment are impacted by the Physical Attributes of UOS

The first hypothesis is tested at the city level across the lower-level and higher-level UOS (**Figure 5**). Social interaction is proxied by the number of users visiting each category of UOS per day, derived from the user survey, by Equation 16:

$$User\ Activity = \sum(No.\ of\ users\ \times Frequency\ of\ visits) \qquad \text{Equation 16}$$

where the frequency of visits is converted to days, so daily is 1 per day, and 1-3 times a year is (2/365) 0.005.

Experiential values in the UOS are used to represent place attachment. Both are tested for the significance of their relationship with the hierarchical level of UOS using the independent sample t-test. The independent sample t-test is a robust statistical tool used to compare the means of two independent groups if there is a statistically significant difference between them, and is commonly used when one variable is continuous (Rasch et al., 2007). This makes it suitable for examining whether user activity and experiential values differ across hierarchical levels.

At the neighbourhood level, indices are calculated to represent social interaction (Equation 17) and place attachment (Equation 18) in the open spaces from the measured indicators detailed in **Table 1**.

$$Social\ Interaction\ Index = \frac{Indices\ of\ (Spatial\ Organization + Accessibility + Spatial\ Distribution)}{3} \qquad \text{Equation 17}$$

$$Place\ Attachment\ Index = \frac{Values\ of\ (Protection + Comfort + Enjoyment)}{3} \times (Frequency\ of\ Visits\ \times Time\ Spent) \qquad \text{Equation 18}$$

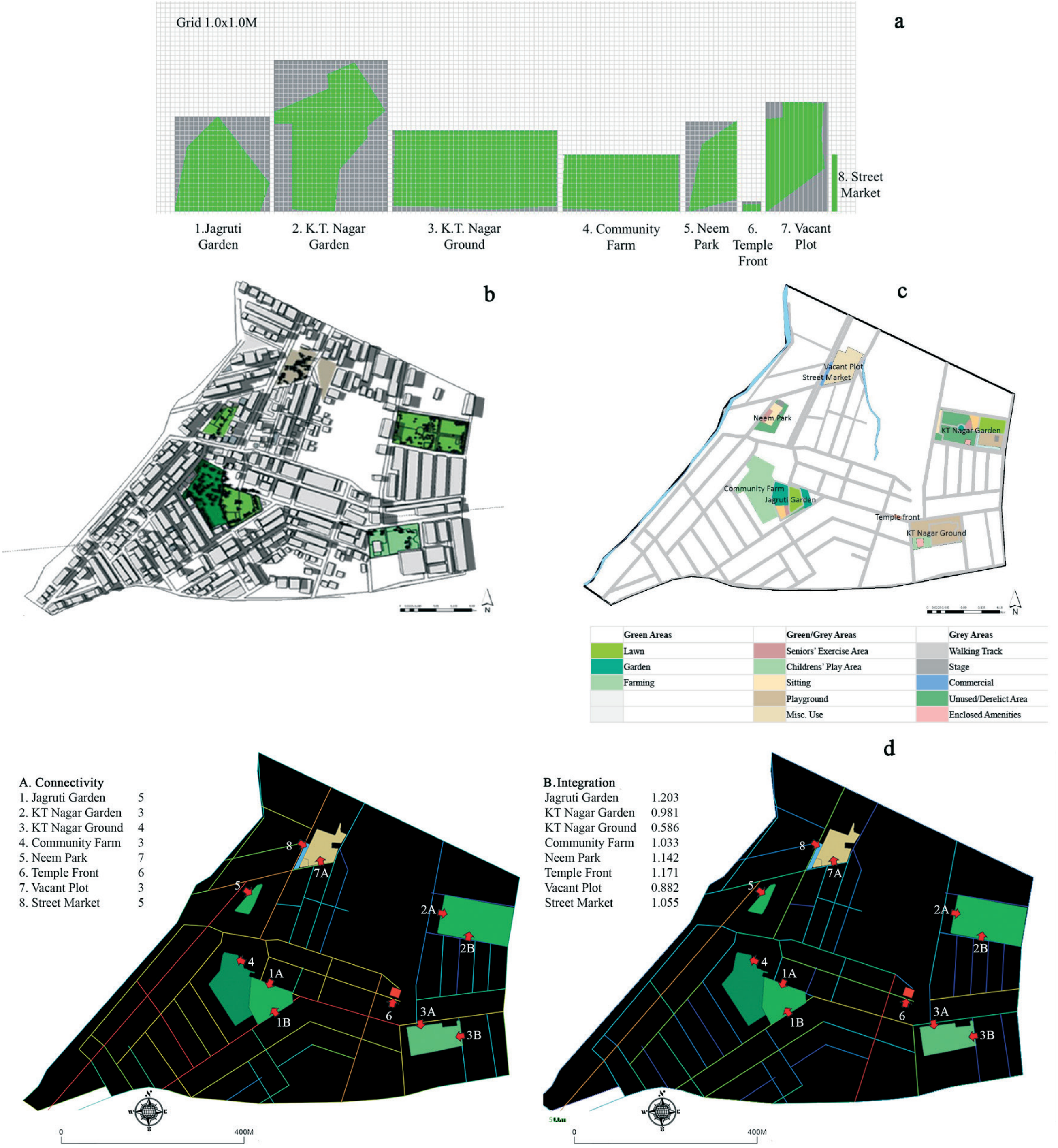


Figure 5 a. Diagrams used for box-counting to calculate the entropy of symmetry of the UOS; **b.** Google SketchUp model of the study area to analyze the shading percentage ; **c.** GIS-generated map showing activity areas in the UOS; **d.** DepthMap generated maps of the connectivity and integration of the selected UOS.

Multiple regression analysis is a popular statistical tool that explains the variance of the dependent variable based on the independent variables (Schroeder et al., 2018). This method is particularly effective for modelling the complex relationships between various factors that describe the physical attributes of the UOS and the indices of social interaction and place attachment, which serve as the dependent variables. The analysis generates a correlation coefficient (R) that ranges from 0 to 1; higher values

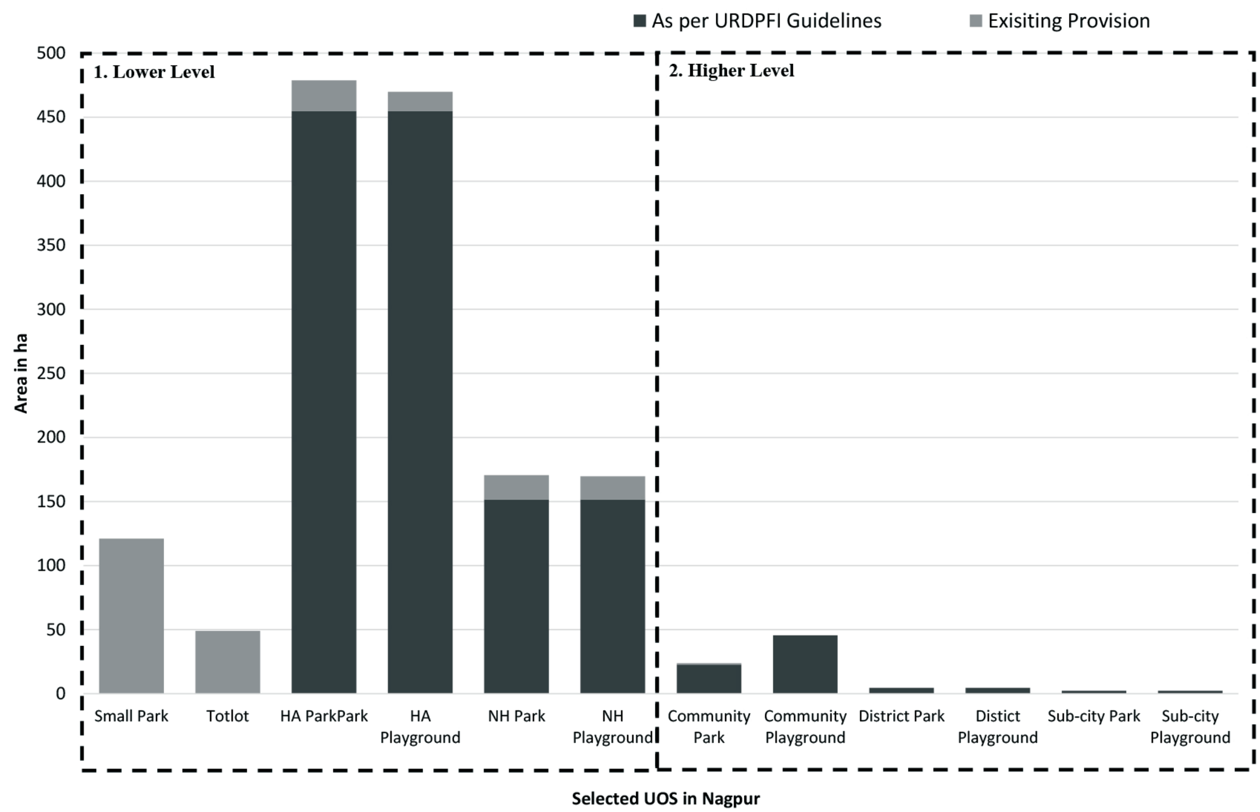


Figure 6. A bar chart comparing the existing area of UOS to the area recommended by URDPFI Guidelines for different hierarchical levels (higher and lower levels).

indicate a stronger relationship between two variables. The f and p of the ANOVA test demonstrate the significance of the regression model and how well the independent variables can predict the dependent variable. The p coefficient represents the probability that the results are due to chance rather than being related to the independent variables. A p-value lower than the standard level of significance of 0.05 indicates that the identified independent variables are likely to cause the observed variations in the dependent variable.

H2: Social Interaction and Place Attachment are impacted by the level of control on UOS planning

At the city level, the results of Equation 12 are classified into planned, semi-planned, and unplanned categories according to the level of control over the planning of the UOS. The demographic data (gender, age, and income) of the participants are used to represent social interactions, as they show the extent to which the UOS is used equally by all members of society. Their perception of experiential values gathered in the online survey is taken as an indicator of place attachment. A multiple regression analysis is conducted, using the data as dependent variables at different planning levels.

At the neighbourhood level, the UOS are categorised into three planning types, and regression is performed to determine if the level of control affects the accessibility of the UOS to both genders, across all ages, and income levels. The test is also used to verify the impact of the control on the user's perception towards protection, comfort, and enjoyment in the spaces. **Figure 7** provides a graphical representation of the statistical analysis performed.

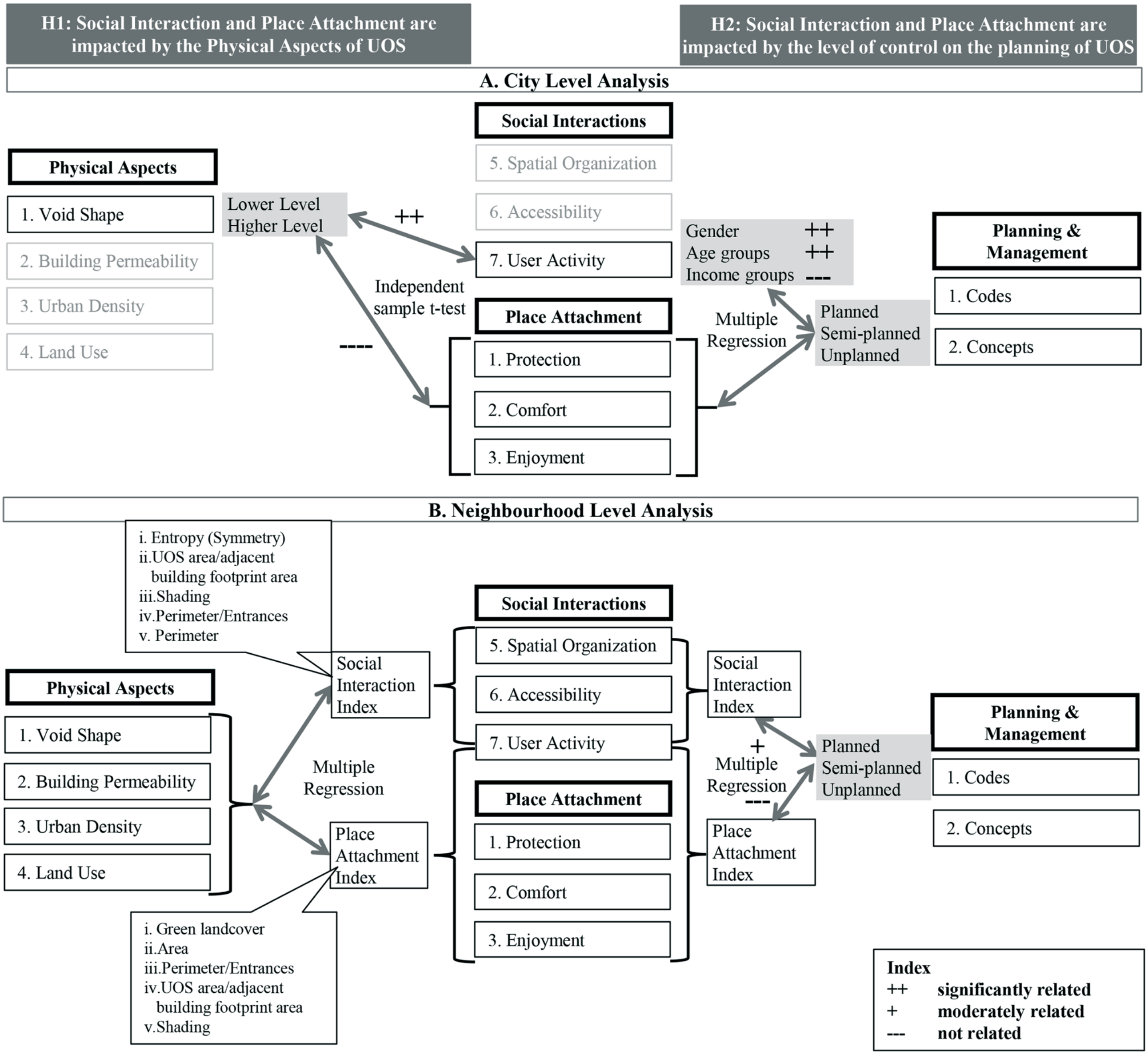


Figure 7. A graphical presentation of the analysis methods used to test the two hypotheses, indicating their results.

RESULTS

A framework (**Figure 1**) is developed to measure the four aspects of UOS and relate them to social interaction and place attachment. The present study uses this tool to test hypotheses H1 and H2 at the city and neighbourhood levels in Nagpur, India. Refer to the Supplementary Data for the results of the statistical analysis.

H1: Social Interaction and Place Attachment are impacted by the Physical Attributes of UOS

At the city level, the independent sample t-tests reveal a significant relationship between social interaction and the hierarchy of the UOS. The results indicate that smaller neighbourhood and housing area UOS support more frequent visits as compared to larger community and city-level UOS. Despite offering more space and facilities, higher-level UOS tend to attract less everyday use and have a weaker social presence, as they are usually more distant and formal. This suggests an inverse relationship between scale and active or diverse use; larger spaces with overly managed facilities may actually hinder social interactions.

At the neighbourhood level, the regression results show that specific physical attributes influence interaction. Spaces with simpler shapes, moderate enclosure, ample greenery, and shading support higher user activity and more balanced distribution across activity areas. Perimeter permeability enhances integration with surrounding streets, increasing unplanned walk-ins. Collectively, these physical attributes strongly shape daily interactions.

Place attachment shows weaker ties to physical attributes. While greenery, shade, and a sense of protection contribute positively, no single physical factor is seen as a strong predictor. Instead, attachment is shaped by cumulative social experiences and experiential values users attach to the space. Neighbourhood UOS, although smaller, supports greater attachment than city-level parks, reflecting their integration into residents' daily lives.

H2: Social Interaction and Place Attachment are impacted by the level of control on the planning of UOS

At the city level, statistical results indicate that the extent of planning and management of UOS partly influences social interaction. Planned spaces attract a more diverse range of age and gender groups, especially women, who perceive these spaces as safer. However, income was not a differentiating factor across planning types (**Table 3b**). Place attachment appears to be similar across planned, semi-planned, and unplanned UOS, suggesting that it does not rely solely on formal planning categories.

At the neighbourhood level, semi-planned and unplanned spaces are actively used by the varied groups because they allow flexible and spontaneous appropriation. The planning type most strongly influences perceptions of safety; planned UOS generate higher feelings of protection (for children after dark and against harsh climatic conditions). However, comfort and enjoyment are less sensitive to levels of control and are more influenced by everyday experience, creativity, and opportunities for informal gathering. It is noted that female users tend to prefer planned UOS due to safety, while many others favour semi-planned neighbourhood-level UOS that combine basic amenities with greater flexibility. This indicates that formal control contributes to feelings of security and inclusivity, but over-regulation can dilute enjoyment and reduce emotional attachment to the space. People often form stronger attachments to smaller, semi-controlled neighbourhood spaces because they can adapt them for community needs.

The findings confirm the first hypothesis (H1): physical characteristics strongly drive social interaction, though their role in attachment is weaker. The second hypothesis (H2) is only partially confirmed: planning and management significantly influence perceptions of safety and women's participation, but overall levels of attachment and enjoyment depend more on daily use and the experiential values people ascribe beyond formal controls.

CONCLUSION

With the rapid growth of cities and an increasing number of people migrating to urban centres, it has become essential for planners to promote social interaction among the diversified population and to increase their experience of public life with feelings of place attachement. The study contributes to the goal by developing and testing a multidimensional framework to assess social interaction and place attachment in UOS, integrating planning and management, physical attributes, user activity patterns, and experiential values. Applied to Nagpur at both the city and neighbourhood levels, the framework tests two hypotheses and leads to three key insights.

Physical attributes of UOS, such as perimeter, area, shading, and green cover, have a significant effect on social interaction, whereas their influence on place attachment is less pronounced. It is revealed that attachment depends more on continued and meaningful social use, user experiences, and the values people ascribe to UOS. Thus, physical features are necessary but not sufficient to encourage place attachment.

When comparing the hierarchy of UOS to their planning types, it is revealed that the neighbourhood-level spaces are more intensively used and valued than the community- and city-level UOS. Despite their greater size and formal facilities, higher-level UOS attract fewer everyday users and generate weaker attachment because they tend to be more regulated, commercialised, or distant. In contrast, smaller neighbourhood UOS are often more flexible and integrated into daily routines, thus supporting higher frequencies of visits, routine encounters, and stronger place bonds.

The study confirms that levels of control affect user activity rather than attachment. Planned UOS foster stronger perceptions of safety and are preferred by female users, yet they do not necessarily encourage greater place attachment. Semi-planned neighbourhood UOS, create more opportunities for enjoyment and interaction by balancing formal provision and user appropriation.

The developed framework allows planners and policymakers to quantify experiential values and the intangible benefits of UOS in a format suitable for robust statistical analysis and practical planning. Also, the framework is scalable from the city to the neighbourhood level. The primary study suggests three directions for UOS planning in the city, i) prioritise neighbourhood UOS that host regular social interactions and generate stronger emotional ties, ii) design for flexibility and protection since users prefer simple, shaded spaces that feel safe yet are adaptable to varied activities, iii) avoid over-regulation as security, comfort, and enjoyment are more effectively fostered through active use and social appropriation rather than tight control. By increasing social interaction in the open spaces and encouraging place attachment, the integration of the urban population is promoted. At the same time, with increased use and connection to UOS, their importance will be ensured so they are not lost to haphazard development and unwise decision-making.

Although the framework quantifies both social interaction and place attachment, the present study does not directly test the statistical relationship between these two social factors. Future research can examine how different types and intensities of social interaction translate into place attachment, recognising that higher interaction does not automatically lead to stronger emotional bonds with a place. Future research can also extend the qualitative inquiry of the framework to address the effect of emotional bonds, memories, and collective experiences on place attachment. A wider survey of UOS and people's perceptions of experiential values can be conducted to collect more comprehensive data on the requirements and preferences of the diverse city population. This can lead to the formulation of city-specific guidelines that will allow planners to conceive UOS that are more appropriate and beneficial to the users.

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KENTSEL AÇIK ALANLARDA SOSYAL ETKİLEŞİM VE MEKÂNA BAĞLILIĞIN ÖLÇÜLMESİ: NAGPUR, HİNDİSTAN ÖRNEĞİ

Kentsel Açık Alanlar (KAA), farklı topluluk grupları arasındaki sosyal etkileşimi güçlendirmekte ve mekâna bağlılık duygusunun oluşmasına katkıda bulunmaktadır. Ne var ki, bu sosyal etkenler, ölçümlerinin güçlüğü nedeniyle KAA planlamasında çoğu zaman göz ardı edilmektedir. Bu çalışma, söz konusu iki etkenin dört KAA boyutunda nicel olarak ele alınmasına yönelik bir çerçeve ortaya koymaktadır: 1. planlama ve yönetim;

2. fiziksel nitelikler; 3. kullanıcı etkinlik örüntüleri; ve 4. deneyimsel değerler. Çerçeve, iki hipotezi sınamaktadır: i) sosyal etkileşim ve mekâna bağlılık, KAA'nın fiziksel nitelikleri tarafından şekillendirilmektedir; ii) bu etkenler, KAA'nın planlanması ve kullanımı üzerindeki denetim düzeyinden de etkilenmektedir. Değerlendirme, Hindistan'ın Nagpur kentindeki KAA'lara odaklanmakta ve hem kent hem de mahalle ölçeklerini kapsamaktadır. Veri toplama sürecinde yerinde gözlemler, kullanıcı anketleri, CBS haritalama ve modelleme yöntemlerinden yararlanılmaktadır. Deneyimsel değerler, Gehl'in Kuramı temel alınarak koruma, konfor ve keyif kategorileri çerçevesinde değerlendirilmektedir. Kullanıcı deneyimi ile KAA nitelikleri arasındaki ilişkiler ise çoklu regresyon analizi ve anlamlılık testleriyle incelenmektedir.

Bulgular, KAA'nın fiziksel özelliklerinin sosyal etkileşimi anlamlı biçimde etkilediğini ortaya koymaktadır. Bununla birlikte, planlama ve yönetimin bu etki üzerindeki payının daha sınırlı olduğu görülmektedir. Öte yandan, mekâna bağlılık, KAA'nın fiziksel niteliklerinden ve planlama süreçlerinden büyük ölçüde bağımsız kalmaktadır. Bu çalışma, sosyal etkileşim ve mekâna bağlılığın farklı KAA ölçeklerinde nicel olarak değerlendirilmesine olanak tanıyan özgün bir çerçeve sunarak bu faktörlerin planlama pratiklerine entegrasyonunu kolaylaştırmaktadır. Bu sayede daha bilinçli ve kapsayıcı bir karar alma sürecine zemin hazırlanmaktadır.

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Anahtar Sözcükler: Kentsel açık alanlar; sosyal etkileşim; mekâna bağlılık; fiziksel nitelikler; kullanıcı etkinlik örüntüsü; deneyimsel değerler; Gehl Kuramı.

A FRAMEWORK FOR THE EMPIRICAL ASSESSMENT OF SOCIAL INTERACTION AND PLACE ATTACHMENT IN URBAN OPEN SPACES: EVIDENCE FROM NAGPUR, INDIA

Urban Open Spaces (UOS) enhance social interactions among diverse community groups and establish place attachment. However, these social factors are often overlooked in UOS planning due to measurement challenges. This study introduces a framework to quantify the two factors across four UOS aspects: 1. planning and management; 2. physical attributes; 3. user activity patterns; and 4. experiential values. The framework tests two hypotheses: i) social interaction and place attachment are influenced by UOS physical attributes, and ii) they are affected by the level of control over the planning and use of UOS. The assessment focuses on UOS in Nagpur, India, at the city and neighbourhood levels. Data collection involves on-site observations, user surveys, GIS mapping, and modelling. Experiential values are assessed using Gehl's Theory, categorised into protection, comfort, and enjoyment. Multiple regression analysis and significance testing examine the relationships between user experience and UOS attributes.

Results indicate that UOS physical characteristics significantly influence social interaction. However, planning and management exert a lesser effect. Conversely, place attachment is largely independent of the UOS physical attributes and planning. This study provides an innovative framework to quantify social interactions and place attachment across different UOS scales, facilitating their integration into planning practices. It thus enables more informed and inclusive decision-making.

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APPENDIX I

	VOID SHAPE				PERMEABILITY		URBAN DENSITY	LANDUSE			SPATIAL ORGANIZATION	ACCESSIBILITY	SPATIAL DISTRIBUTION
	sqm	m	m	bits	ratio		ratio	ratio	% of total area	% of total area			
Name of UOS	**Area**	**Perimeter**	**Aspect Ratio A/P**	**Entropy (symmetry)**	**Perimeter/ entrance ratio**	**Opening density**	**UOS area/ Adjacent building footprint area**	**Entropy of Adjacent building use**	**Green Landcover**	**Shading**	**Spatial Organization Index**	**Accessibility Index**	**Spatial Distribution Index**
Jagruti Garden	6449	321	20.09	0.94	160.50	2.87	2.32	0.00	0.63	0.35	6.05	0.43	1.81
KT Nagar Garden	13789	500	27.58	0.38	166.67	2.17	1.05	1.05	0.15	0.32	0.75	0.50	39.00
KT Nagar Ground	8027	375	21.41	0.32	187.50	5.28	1.23	0.69	0.00	0.26	4.47	0.30	4.62
Community Farm	9575	496	19.30	1.00	496.00	0.44	3.02	0.00	1.00	0.62	1.00	0.44	1.80
Neem Park	3513	260	13.51	0.96	260.00	0.84	1.89	0.48	0.00	0.33	0.87	0.25	72.00
Temple front	129	51	2.53	0.54	51.00	0.87	0.08	0.00	0.00	0.10	1.00	0.58	0.00
Vacant Plot	5169	319	16.20	0.89	319.00	4.54	1.48	0.47	0.00	0.52	0.00	0.64	0.46
Street Market	239	131	1.82	0.38	43.67	6.79	0.25	0.67	0.00	0.00	0.00	0.43	44.00

Supplementary Table I. Data collected fot the physical aspects of chosen neighborhood UOS using developed framework.

APPENDIX II

	Name of Selected Open Space	PROTECTION: Safety	Natural Beauty	Climate	P	COMFORT: Accessible	Recreational Opportunity	Physical Health	Social Ties	Economic Opportunity	Psychological Well Being	C	ENJOYMENT: Aesthetic Enjoyment	Creative Use	Religion/ Culture	E
1	Jagruti Garden	2.20	2.70	1.30	2.07	2.75	1.45	3.60	1.40	1.20	4.05	2.41	3.85	1.80	1.10	2.25
2	KT Nagar Garden	4.00	2.94	1.50	2.81	3.06	3.38	4.06	2.63	1.56	3.81	3.08	2.31	1.75	1.56	1.88
3	KT Nagar Ground	3.50	0.00	0.00	1.17	3.00	2.25	3.75	2.25	0.25	2.75	2.38	2.25	0.25	0.00	0.83
4	Community Farm	2.50	4.83	4.33	3.89	1.33	3.50	4.83	4.00	1.50	2.67	2.97	3.67	3.50	0.00	2.39
5	Neem Park	2.50	0.00	1.75	1.42	4.00	2.25	3.50	1.75	0.50	3.50	2.58	1.75	2.00	2.25	2.00
6	Vacant Area	0.50	0.00	1.50	0.67	3.00	3.50	0.00	3.50	2.50	1.00	2.25	1.00	3.50	2.50	2.33
7	Street Market	1.50	0.00	1.50	1.00	3.50	2.00	0.25	3.00	3.75	1.75	2.38	1.50	0.25	0.00	0.58
8	Temple front	0.25	0.00	2.25	0.83	5.00	2.25	2.00	3.50	1.00	4.25	3.00	3.75	2.75	4.25	3.58
	TOTAL	**2.12**	**1.31**	**1.77**	**1.73**	**3.21**	**2.57**	**2.75**	**2.75**	**1.53**	**2.97**	**2.63**	**2.51**	**1.98**	**1.46**	**1.98**

Very Low	Low	Moderate	High	Very High
1	2	3	4	5

Supplementary Table II. Experiential values in selected neighborhood open spaces quantifies from user survey.

APPENDIX III

City Level

Independent Samples T-Test

	t	df	p
User Activity	8.386	8	**< .001**

Note. Student's t-test.

Independent Samples T-Test

	t	df	p
Experiential Value	0.601	8	**0.565**

Note. Student's t-test.

Neighbourhood Level

	Regression statistics R	R^2	ANOVA F	p	Coefficients p-value				
Social interaction index					Entropy (symmetry)	UOS area/ footprint	Shading	Perimeter/ entrances	Perimeter
	0.982	0.964	10.807	0.087	0.034	0.023	0.064	0.047	0.055
Place attachment index					. Green cover	Area	Perimeter/ Entrances	UOS Area/ Footprint	Shading
	0.971	0.943	6.563	6.563	0.073	0.289	0.129	0.23	0.28

H1: Social interaction and place attachment are impacted by the physical aspects of UOS.

APPENDIX IV

City Level

		Regression statistics		ANOVA		
		R	R^2	F	p	Coefficients
Social interaction index	Control	0.718	0.515	6.373	0.045	**0.045**
Place attachment Index	Control	0.171	0.029	0.181	0.685	**0.685**

Neighbourhood Level

		Regression statistics		ANOVA		p-value		
		R	R^2	F	p	Planned	Semi-planned	Unplanned
Social interaction index	Gender	**0.742**	0.551	11.03	< .001	**0.322**	**< .001**	**< .001**
	Age	**0.624**	0.39	5.743	0.004	**0.517**	**< .001**	**0.496**
	Income	**0.384**	0.147	1.556	0.223	**0.419**	**0.128**	**0.057**
place attachment Index	Protection	**0.183**	0.033	0.311	0.817	**0.72**	**0.599**	**0.72**
	Comfort	**0.388**	0.151	1.596	0.213	**0.125**	**0.841**	**0.394**
	Enjoyment	**0.348**	0.121	1.237	0.316	**0.071**	**0.842**	**0.346**

H2: Social interaction and place attachment are impacted by the level of control on UOS planning.