Campus Commons: Analysis of IIT Patna's Public open Spaces

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ABSTRACT: The Public open spaces offer amenities including areas for social interaction and physical activity, which are crucial for the overall wellness of society and the enhancement of living quality. Many studies on POSs have been conducted in developed countries (the US, Australia, and Europe, particularly Germany, Spain, and France). POSs for the Indian context haven't been thoroughly studied, though. Using importance-performance analysis (IPA), this study attempts to investigate the role and effectiveness of public open spaces on the campus of National Institute of Technology, Patna, India. It has been noted that stakeholders' perceptions of the importance & satisfaction, from the use of public open spaces within the IIT Patna campus, varies. Consequently, this study could be useful in determining the importance and satisfaction of public open spaces, enabling the prioritization of these areas in order to enhance management and restore them in order to accomplish environmental sustainability locally. Furthermore, this study recommends that public open spaces' benefits to education, recreation, & the environment be taken into account by those in authority over campus planning early on.

Keywords: Public Open Spaces, Importance-performance analysis, Indian Institute of Technology Patna, Importance & Satisfaction, Campus Planning.

I.   INTRODUCTION

The open spaces within an educational campus are essential forms of space, and they play a critical role in establishing a vibrant campus environment. Campus-public spaces are most remembered as (a) outdoor spaces primarily used as an interactive environment, where people congregate to walk, talk, study, and relax and as (b) incidental spaces where people encounter socio-cultural as well as leisure activities [1]. Usually, students tend to remember the open spaces of their university more vividly than its buildings [2]. A public open space (POS) can be defined as "an area or place that is open and accessible to all the citizens, regardless of gender, race, ethnicity, age or socio-economic level". The primary role of a POS is to cater to the needs and provide satisfaction to its users [3]. Carr et al. (1992) refer to POSs as 'the stage on which the drama of communal life unfolds[4]. According to Gehl [5] POSs can take on various forms such as squares, streets, walkways, and waterfront spaces. Public Open Spaces (POS) play a crucial role in promoting environmental sustainability. The construction of campuses in developing countries has seen a rapid increase, but it is now moving into a phase of gradual advancement. The number of newly constructed campuses is decreasing, and the construction focus is shifting from "speed first" to "quality first" [6]. It is imperative for urban planners and policymakers to acknowledge and incorporate the value of POS in their strategies for sustainable urban development. The United Nations (UN) formulated sustainable development goals (SDGs) that emphasize the importance of addressing the socio-economic and environmental aspects of Public Open Spaces (POSs) and establishing connections and balance between these dimensions [7]. Target 11.7 outlines a specific objective for the year 2030, aiming to ensure universal access to secure and inclusive POSs, with a particular focus on children, older individuals, women, and those with disabilities.

Public open spaces (POS) are integral to the development of a vibrant and dynamic campus environment. These spaces, which encompass parks, gardens, courtyards, and recreational areas, serve as essential components of campus life by providing multifaceted benefits that enhance the social, physical, mental, environmental, and educational experiences of the campus community.

- One of the most significant contributions of Public Open Spaces (POSs) is their role in fostering community and social interaction. These spaces serve as communal areas where students, faculty, and staff can gather, interact, and build relationships. The availability of Public Open Spaces (POSs) facilitates informal social interactions and organized events, promoting a sense of belonging and community cohesion[8] According to Francis, Giles-Corti, Wood, and Knuiman, well-designed public spaces encourage social interaction and enhance community well-being, which is critical in an academic setting where collaboration and networking are vital [9]

- Public Open Spaces (POSs) provide essential venues for physical activities such as walking, jogging, cycling, and various sports. Regular physical activity is crucial for maintaining physical health and fitness. Open spaces on campus encourage students and staff to engage in outdoor activities, promoting a healthier lifestyle. A study by Bedimo-Rung, Mowen, and Cohen highlights the importance of accessible parks and recreation areas in fostering physical activity and improving public health outcomes [10]

- The mental health benefits of Public Open Spaces (POSs) are well-documented. Natural environments have a restorative effect on mental well-being, reducing stress, anxiety, and depression while enhancing mood and cognitive function[11]. Kaplan and Kaplan's Attention Restoration Theory posits that natural settings help restore depleted cognitive resources, improving focus and overall mental health [12]. The opportunity to spend time in green, open spaces provides a necessary respite from academic pressures, contributing to better mental health and increased academic performance[13].

- From an environmental perspective, Public Open Spaces (POSs) contribute significantly to the sustainability and ecological health of campus environments. Green spaces improve air quality, mitigate the urban heat island effect, and support biodiversity by providing habitats for various species. Moreover, Public Open Spaces (POSs) can be designed to manage stormwater runoff, reducing the risk of flooding, and improving water quality. According to a study by Gill, Handley, Ennos, and Pauleit, urban green spaces play a crucial role in enhancing urban resilience and sustainability[14].

- The aesthetic value of Public Open Spaces (POSs) enhances the visual appeal of the campus, creating an inviting and inspiring atmosphere. Beautifully landscaped gardens and thoughtfully designed open areas contribute to the overall attractiveness of the campus, making it a more pleasant place to study and work. Additionally, Public Open Spaces (POSs) serve as living laboratories for students studying environmental science, botany, landscape architecture, and other disciplines. These spaces provide hands-on learning opportunities and facilitate experiential education, as noted by Louv in his discussion on the importance of nature-based learning [15].

Several previous research investigations have explored the significance of Public Open Spaces (POSs) within urban settings, aiming to enhance the well-being of urban inhabitants and finding various benefits across social, environmental, health, and economic domains [16]. Most studies investigating the functions of POSs and understanding stakeholder perspectives have been conducted internationally, with a particular focus on Europe [17] and the United States [18]. Preliminary research on university campuses concentrated on the comprehensive design of the campus, examining it from a morphological and typological perspective [6]. Several scholars suggested a reconsideration of university campus planning by incorporating urban planning theories and methodologies, advocating for the integration of urban development concepts. These studies offered a theoretical framework and design strategies that have influenced campus and building planning and design for years. Attention Restoration Theory suggests that natural settings provide restorative experiences that alleviate mental fatigue and enhance cognitive functioning[12]. These findings are supported by a study, which demonstrated that residents with access to green spaces experienced lower levels of stress and better overall health [19]. Public Open Spaces (POSs) also play a significant role in fostering social cohesion and

374

community engagement. Francis found that well-designed public spaces encourage social interaction and enhance community well-being [9]. Gehl further emphasizes that public spaces contribute to vibrant urban life by providing areas for people to gather, interact, and participate in communal activities [3] Study shows that effective academic open spaces enhance students' educational outlook, behavior, and health, improve quality of life, and provide psychological comfort. Frequent users handle academic challenges and apply knowledge better than infrequent users [20]

India, home to the world's second-largest student population in higher education, boasts 1,070 universities and 23 IITs as of April 2023, according to the UGC, renowned for their educational excellence [21]. However, the influence of design standards and considerations—covering both physical and psychosocial aspects, along with quantitative and qualitative factors—on students' perceptions and responses remains unstudied in India. A major shortcoming in university campus planning and design has been the neglect of users' preferences and expectations [3]. Limited research has been conducted on Public Open Spaces (POSs) within the context of Indian universities, and there is a lack of studies evaluating the importance and performance of POSs, as well as the disparities between importance and performance. Nagendra and Gopal highlight the challenges faced by urban green spaces in India, including encroachment, inadequate maintenance, and limited public awareness about the benefits of green spaces. These challenges are exacerbated by the high population density and rapid urbanization, which often lead to the neglect of Public Open Spaces (POSs) in urban planning and campus development [22]

The design of open spaces (OS) and the physical environment within educational campuses significantly impacts students' well-being, Cognitive abilities, and mental health [23, 24]. It also plays a vital role in attention restoration as well as contributes to a positive educational experience [23-28]. Moreover, emphasizing the importance of open spaces and their role in augmenting students' emotional experiences can alleviate the stress associated with academic routines and examinations, ultimately leading to improved academic outcomes [29], [30]. Effective planning and management are needed for the management and restoration of POS's, to ensure the provision of variety of land uses to foster environmental sustainability [31]. The underutilization and deterioration of public open spaces (POSs) are a result of a lack of awareness, inefficient management, and maintenance, which affects the stakeholder's everyday life. It's vital to understand the role of POSs in stakeholders' everyday lives at a micro level, such as university campus for the effective management, maintenance, and planning of public open spaces (POSs) as well as is essential for improving education, fostering environmental well-being, and promoting social cohesion. Engaging with stakeholders enables planners to create environments that enhance well-being, academic performance, and social cohesion. This collaborative approach fosters thoughtful, sustainable, and successful campus development, aligning with the broader educational mission and community values. However, the design, availability, and management of these spaces can significantly influence their utilization and impact on student life [32-34].

The study was sparked after a review of earlier research identified several major gaps.

- First off, there is a scarcity of research on how individuals use outdoor campus spaces, though these spaces significantly influence students' and faculty's perceptions of the campus [6]. Open spaces are crucial for enhancing quality of life within educational institutions [35, 36] to understand the relationship between outdoor spaces and students' needs, particularly regarding what makes these spaces appealing and meaningful for university students.

- Secondly, in previous research, POS's have been studied and analyzed in an urban context or city level in Indian cities i.e., Chennai [37], Bengaluru [38, 39] Pune [40], Nagpur [41] from various perspective. However, there is a lack of research conducted at a local scale, specifically focusing on Indian university campuses. However, the student's perception of POSs in the Indian context remains unexplored.

- Thirdly, India is home to the second-largest student population pursuing higher education. As of April 2023, the UGC reports there are 1,070 universities and 23 NITs, renowned for their educational excellence and under the Ministry of Education. According to the UK India Business Council, by 2030, India is expected to have 140 million individuals in the college-going age group. Currently, 1,070 universities educate 41.4 million students. To meet the growing demand and improve quality, India needs at least 1,500 institutions [21]. However, the impact of design standards on students' perceptions

remains unexamined, and a major flaw in campus planning is the neglect of users' preferences and expectations.

Considering these research gaps, there is a need for research to explore the significance of public open spaces (POS) through importance-performance analysis (IPA) based on stakeholder perceptions. This approach can help identify disparities between perceived importance and actual performance, thereby offering insights for effective planning strategies. To conduct this study, the campus of the Indian Institute of Technology (IIT), Patna is chosen.

Importance-Performance Analysis (IPA) was created to evaluate customer satisfaction [42], [43]and has been extensively used in various domains including tourism management, healthcare services, education, and ecosystem services[44-49]. A key advantage of the IPA approach is its utilization of both importance and performance factors to unveil satisfaction levels. Importance-Performance Analysis (IPA) is a strategic management tool used to evaluate and prioritize the factors that affect a service or product. It involves assessing the importance of various attributes to stakeholders and measuring the performance of these attributes. The goal is to identify areas where performance meets or exceeds expectations, and areas needing improvement. According to Martilla and James [42], who introduced the concept, IPA involves plotting attributes on a matrix where one axis represents the importance of the attribute and the other represents the performance level. This visual representation helps organizations identify which areas require improvement and which are performing well. By focusing on attributes with high importance but low performance, organizations can strategically allocate resources and improve overall effectiveness. As stated by Baird [50] post-occupancy evaluation (POE) is described as "a generic term for a variety of general programs and procedures as well as specific techniques for the evaluation of existing buildings and facilities". POE is commonly used in green building development for evaluating building performance [51, 52] with a specific focus on systematically analyzing occupant perceptions [53]. Besides their application in architecture and building contexts, POE techniques have been extensively used in areas such as fields of residential satisfaction, housing facilities, and thermal environmental assessment [54-59]. Nevertheless, despite their extensive use, there have been no studies conducted to evaluate the satisfaction levels pertaining to Public Open Spaces (POSs) for sustainable management and restoration. In this research, IPA has been used for a systematic analysis of the importance and performance of Public Open Spaces (POSs) at Indian Institute of Technology (IIT), Patna, India.

The objective of this paper is to evaluate stakeholder satisfaction—including students, faculty, non-teaching staff, and alumni visitors—with the public open spaces (POS) on the IIT Patna campus as they experience them in their daily lives. The study involves calculating the importance and performance scores for each POS, derived from respondent feedback, to identify areas of strength and those requiring improvement.

II. MATERIAL AND METHOD

The Materials and Methods section encapsulates the blueprint of the research endeavor, meticulously delineating the tools, procedures, and approaches employed to explore the research questions or hypotheses. This section serves as a detailed roadmap, elucidating the systematic methodology adopted to gather, analyze, and interpret data with precision and integrity. Beginning with a comprehensive description of the participants or sample selection, it presents a detailed portrait of the individuals or entities involved in the study, outlining the demographic characteristics and selection criteria. Then, the study area and the rationale behind selecting it has been discussed in detail. Subsequently, the research design is explained, illuminating the overarching structure guiding the study, whether it be qualitative, quantitative, experimental, or employing mixed methodologies. This section meticulously details the materials or instruments utilized, delving into the specifics of the tools, surveys, or equipment harnessed to collect data. The procedure or data collection segment elaborates on the step-by-step process undertaken during the research, providing transparency regarding the protocols followed. The sampling method has been discussed in detail under data collection. Moreover, the section addresses the approach to data analysis, offering insights into the methodologies employed to derive meaningful interpretations from the gathered information. Ethical considerations, limitations, validity, reliability, and, if applicable, statistical analyses are also conscientiously documented, ensuring a comprehensive and transparent portrayal of the research methodology.

1   STUDY AREA

IIT Patna, founded in 2015, is a centrally funded technical institute (CFTI) and is recognized as an Institute of National Importance by the Government of India. It is one of the second-generation IITs established by an Act of the Indian Parliament on 6 August 2008. The campus encompasses a gated, urban environment, characterized by an 'autonomous urban fabric,' spanning 501 acres (203 ha). The rationale behind selecting IIT Patna includes several key factors:

- Modern Infrastructure and Recent Development: IIT Patna, established in 2008, is one of the newer IITs, featuring contemporary infrastructure and campus design. This relatively recent development allows for the study of modern campus planning principles and the integration of public open spaces in a contemporary educational environment. The insights gained from IIT Patna can be particularly relevant for understanding how current design practices impact student life and campus functionality.

- Growing Student Population: With a growing student population, IIT Patna offers a dynamic environment to observe how public open spaces cater to the needs of an expanding academic community. The interaction between increasing student numbers and the available POS can provide valuable information on the adequacy and effectiveness of these spaces in accommodating a larger population.

- Emphasis on Holistic Education: IIT Patna emphasizes holistic education, aiming to foster not only academic excellence, but also physical well-being and social engagement among its students. The institute's commitment to comprehensive student development makes it a suitable case study for examining the impact of POS.

- Unique Climatic and Cultural Context: Located in Bihar, IIT Patna operates within a unique climatic and cultural context distinct from other regions in India. This geographical and cultural specificity offers an opportunity to explore how local climate and cultural practices influence the design and use of public open spaces. Understanding these contextual factors can provide broader insights into the adaptability and effectiveness of POS in different settings.

- Opportunities for Comparative Analysis: Studying IIT Patna allows for potential comparative analysis with other IITs and universities across India. By examining the POS at IIT Patna, researchers can compare findings with those from other institutions to identify common trends, unique challenges, and best practices in campus planning and design. Such comparisons can enhance the overall understanding of effective POS integration in higher education institutions.

2   DATA COLLECTION

2.1 Identification and Classification of POS

Individuals view POS' importance differently, depending on whether they are using it for pleasure, varied people have varied viewpoints on the value of a POS, such as those related to recreation, the environment, or education. Depending on one's viewpoint—educational or environmental - a POS may or may not be deemed valuable. A POS's perceived worth may change over time depending on both its significance and effectiveness. The social preference approach (SPA) has been used in this study to assess Public open space (POSs) at the institution. This approach has previously been used in different studies in Saudi Arabia [60] and Jeddah [61]. The social preference approach (SPA) is a collective method that considers perception, personal knowledge, and attachment to the point of sale to better understand the social value of spaces utilized by individuals and society. SPA is an integrated approach that helps to grasp the social significance of these spaces by accounting for how people perceive, connect with, and feel attached to them[61].

POSs have been identified through direct observation and a field survey. As in the table below, POSs have been classified into sixteen types; Gardens(Gd_n), Green spaces(Gr_s), Departmental corridors(D_cdr), Department courtyards(D_crt), Department lawns(D_lwn), Plaza Infront of Academic building(P_ac), Plaza Infront of Administrative building(P_ad), Open spaces Infront of canteens(Os_c), Chowks/Squares/Informal nodes(Nd_cs), Bicycle trail(Bi_t), Walking trail(Wa_t), Water body(W_bd), Sports field/Play field(S_rt),

377

Maidan/Multipurpose outdoor spaces(M_os), Lookout spaces(L_Ss) and Vacant/Unplanned/Unclassified spaces(Un_ss).

Three perspectives are reflected in the types of POS chosen. First, the recreational perspective. At IIT Patna, this perspective is primarily focused on the gardens, plazas, and open areas close to the canteen, as well as the courtyards and corridors that are utilized for recreation. Because university stakeholders enjoy socializing and getting together with friends, the POSs offer a variety of cultural and recreational services. Second, POSs with environmental features like cooling effects and air quality control are taken into account from the environmental perspective. Understanding the environmental benefit of POSs heavily depends on assessments of their environmental features. For instance, a university's gardens and water body significantly contribute to the provision of diverse ecological benefits (such as the regulation of air quality, cooling impact, and air temperature). Thirdly, the educational perspective takes into account POSs' capacity to raise the institution's educational value. Stakeholders can use POS time for either individual or group study, mental refreshment, and education, especially for students and faculty. It is crucial that POSs have instructional value for stakeholders, as IIT Patna is an educational institution. From an educational standpoint, IIT Patna's lawns, courtyards, corridors, and plazas are important features.

This study's interpretation of the three perspectives has helped us comprehend the overall significance and effectiveness of POS's. These three viewpoints were applied to the questionnaire to assess the performance and significance of POSs [61].

2.2 Collection of data

The collection of data was conducted through both web-based online surveys and on-field surveys, with personal interaction with the respondents. A total of 378 respondents were selected as the sample size for both the surveys through Random Sampling Method where 50% of the respondents were selected for the field survey and 50% were selected for online surveys. Hazelrigg, 2009 [62] suggest Cochran Method (i.e. formula) for the determination of sample size. This study adopts the same method for sample calculation, it describes as:

$$\frac{z^2 \times P \times (1-P)/e^2}{1+(Z^2 \times P(1-P)/e^2 N)} \tag{1}$$

Where N= Footfall Count of seven days, P = Proportion/percentage picking a choice = 0.5, e = Sampling error or Margin error = 5% = 0.05, and Z= Z score or confidence level = 95% = 1.96.

Sixteen POS kinds were chosen for the questionnaire depending on the university's landscape. The participants were asked, "Do you agree the POSs within the IIT Patna campus can enhance the quality of life of stakeholders?" A 5-point Likert scale, with 1 denoting not at all satisfied and 5 denoting extremely satisfied, was used to capture the perceived relevance of the various POS categories. Furthermore, the participants were asked "Do you agree the performance of POSs is satisfactory on the IIT Patna campus to enhance recreational, educational & environmental values?" to assess the performance of the listed POSs. The performance was assessed on a 5-point Likert scale ranging from strongly disagree to agree strongly. Participants were also asked about the importance and satisfaction of each sixteen POSs for recreation and academic purposes in the IIT Patna campus, to analyze the importance and user satisfaction of the different POSs for the stakeholders. Again a 5-point Linkert scale ranging from Not important at all to extremely important and very dissatisfied to very satisfied for examining importance and satisfaction of POS respectively was used.

2.3 Field Survey and Observations

Public Open Space (POS) types were chosen taking into consideration the university's landscape. The respondents were asked to fill out a pre-tested questionnaire after being chosen at random from among those using the various POS systems on the university campus. Another important source of information for this study was focus group discussions and respondent interviews. The questionnaire (Table 1) for the field survey and the online survey were kept the same.

2.4 Online Questionnaire

An online survey (Table 1) was implemented to look at how important and satisfied people thought POSs were on the IIT Patna campus. Google Forms, an online survey tool, was used to build the online survey. Links to the survey were posted on various social media platforms. Through the institution site, links to the questionnaire were additionally emailed to the stakeholders. On the site's home page, there were instructions to help with comprehending the information's purpose. The online questionnaire was used to poll 378 respondents (Table 2) in total.

Table 1. Questionnaire for the assessment of Importance-Performance Analysis (IPA) for Public open space (POS's) in IIT Patna campus

	Importance Level		
	1. According to you, what is the importance of the POSs (public open spaces) for the recreation purpose in the IIT Patna campus?		
A1	Gardens	5	Not important at all
A2	Green spaces	4	Somewhat Important
A3	Department corridors	3	Important
A4	Department courtyards	2	Very Important
A5	Department lawns	1	Extremely Important
A6	Plaza Infront of Academic building		
A7	Plaza Infront of administrative building		
A8	Open spaces Infront of canteens		
A9	Chowks/Squares/Informal nodes		
A10	Bicycle trail		
A11	Walking trail		
A12	Water body		
A13	Sports field/Play field		
A14	Maidan/Multipurpose outdoor spaces		
A15	Lookout spaces		
A16	Vacant/unplanned/Unclassified spaces		
	2. According to you, what is the importance of the POSs (public open spaces) for the academic purpose in the IIT Patna campus?		
A1	Gardens	5	Not important at all
A2	Green spaces	4	Somewhat Important
A3	Department corridors	3	Important
A4	Department courtyards	2	Very Important
A5	Department lawns	1	Extremely Important
A6	Plaza Infront of Academic building		
A7	Plaza Infront of administrative building		
A8	Open spaces Infront of canteens		
A9	Chowks/Squares/Informal nodes		
A10	Bicycle trail		
A11	Walking trail		
A12	Water body		
A13	Sports field/Play field		
A14	Maidan/Multipurpose outdoor spaces		
A15	Lookout spaces		
A16	Vacant/unplanned/Unclassified spaces		
	Satisfaction Level		
	3. How satisfied are you with the following POSs (public open spaces) for the recreation purpose in the IIT Patna campus?		
A1	Gardens	5	Very dissatisfied
A2	Green spaces	4	Dissatisfied

A3	Department corridors	3	Neutral
A4	Department courtyards	2	Satisfied
A5	Department lawns	1	Very satisfied
A6	Plaza Infront of Academic building		
A7	Plaza Infront of administrative building		
A8	Open spaces Infront of canteens		
A9	Chowks/Squares/Informal nodes		
A10	Bicycle trail		
A11	Walking trail		
A12	Water body		
A13	Sports field/Play field		
A14	Maidan/Multipurpose outdoor spaces		
A15	Lookout spaces		
A16	Vacant/unplanned/Unclassified spaces		

4. How satisfied are you with the following POSs (public open spaces) for the academic purpose in the IIT Patna campus?

A1	Gardens	5	Very dissatisfied
A2	Green spaces	4	Dissatisfied
A3	Department corridors	3	Neutral
A4	Department courtyards	2	Satisfied
A5	Department lawns	1	Very satisfied
A6	Plaza Infront of Academic building		
A7	Plaza Infront of administrative building		
A8	Open spaces Infront of canteens		
A9	Chowks/Squares/Informal nodes		
A10	Bicycle trail		
A11	Walking trail		
A12	Water body		
A13	Sports field/Play field		
A14	Maidan/Multipurpose outdoor spaces		
A15	Lookout spaces		
A16	Vacant/unplanned/Unclassified spaces		

5. Do you agree the performance of POSs (Public open space) is satisfactory on the IIT Patna campus to enhance recreational, educational, and environmental value?

5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly disagree

6. Do you agree the POSs within the IIT Patna campus can enhance the quality of life of stakeholders?

5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly disagree

7. How satisfied are you with your overall POS's (Public open spaces) in the IIT Patna campus?

5	Very satisfied
4	Satisfied
3	Neutral
2	Dissatisfied
1	Very dissatisfied

8. Name: _____ 9. Gender: _____

380

10.	Education Level: _____	11.	Type of Residency
	High school: _____		Student
	Diploma: _____		Faculty
	Bachelors: _____		Alumni
	Masters: _____		Technical Staff
	PhD: _____		Administrative staff
11.	Age:		
	<24	45–54	
	25–34	55–60	
	35–44	>60	

Table 2. Profile of respondents

Domain	Profile	Respondent (n=378)	Percent (%)
Gender	Male	189	50.00
	Female	189	50.00
Educational Level	High school	36	9.52
	Diploma	9	2.38
	Bachelors	153	40.48
	Masters	126	33.33
	PhD	54	14.29
Type of residency	Student	279	73.81
	Faculty	45	11.90
	Alumni	27	7.14
	Technical Staff	18	4.76
	Administrative staff	9	2.38
Age	<24	189	50.00
	25–34	90	23.81
	35–44	63	16.67
	45–54	18	4.76
	55–60	18	4.76
	>60	0	0.00

3   DATA ANALYSIS

3.1 Importance-Performance Analysis (IPA) of Public Open Spaces

IPA methods are frequently employed to assess service quality. To understand customer satisfaction based on service performance, IPA was developed in business and marketing [42] Since then, IPA has been applied to a variety of fields, including education, health care, tourism, and green initiatives. The IPA technique makes it simple to evaluate differences between a service's performance and importance [62]. In this study, the effectiveness and significance of several POS kinds were investigated, and the degree of satisfaction among the social groups that the POSs on campus catered to was evaluated, all using IPA Grid (Figure 1).

An improvement index for point-of-sale systems (POSs) was created to evaluate the significance of POSs as viewed by stakeholders.

$$Ipos=(ISpos-PSpos)/RIpos \qquad (2)$$

$$RIpos=(ISpos-ISposmin)/(ISposmax-ISposmin) \qquad (3)$$

Where *RIpos* is the relative significance of a point of sale; *ISposmax* and *IPposmin* are the maximum and minimum importance scores of a point of sale, respectively; *Ipos* is the improvement index for a particular type of point of sale; and *PSpos* is the performance score. An increased index value denotes a significant mismatch between performance and relevance, implying that the relevant POS must be improved immediately [61].
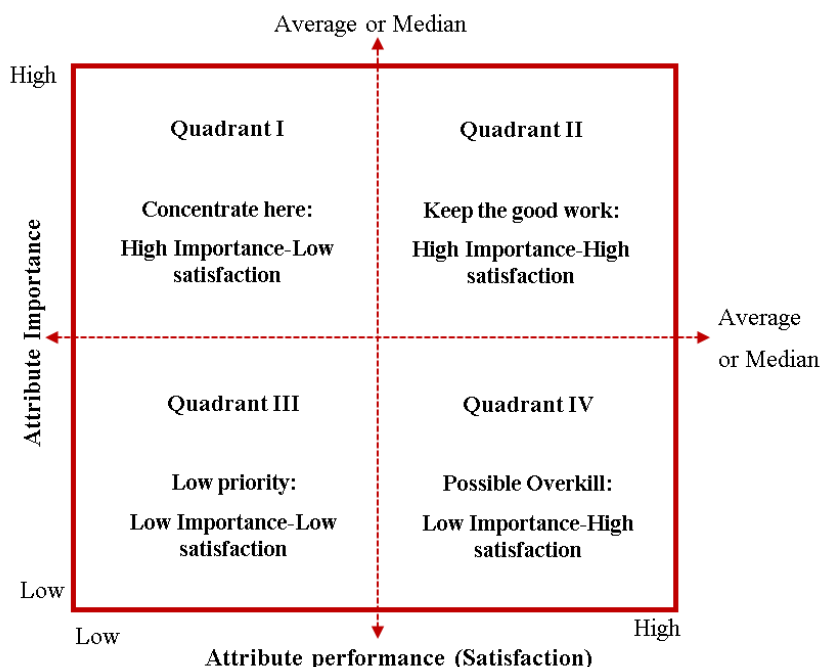

FIGURE 1. Public open space (POS's) IPA Grid

3.2 Measuring Discrepancies

Evaluating a POS type's satisfaction and importance is insufficient. Prioritizing POS kinds and improving the university campus's overall POS system requires the application of this data. Additionally, improving POS management and advancing stakeholder well-being depend on recognizing satisfaction and performance. An attempt was made to investigate these discrepancies in this study, which are impacted by variables like accessibility, availability, and stakeholder dependence for every POSs type.

3.3 Focus Group Discussion and (POE) Post-Occupancy Evaluation

On the IIT Patna campus, satisfaction levels for various POS types were determined through the use of post-occupancy evaluation (POE). Focus group talks are highly helpful in this situation for evaluating a complicated socio-technical system. Using a 5-point Likert scale that goes from extremely satisfied (5) to very dissatisfied (1), the POE method was utilized in this study to determine the stakeholders' perceived degree of satisfaction.

Research concerns were identified through questionnaires, and then focus groups were conducted to gather more qualitative data from stakeholders. Stakeholders from various professions and educational backgrounds participated in the focus groups (such as students, faculty members, and staff). The stakeholders were chosen based on two criteria: (i) familiarity with the university, especially among stakeholders; and (ii) familiarity with POSs on the campus of IIT Patna campus. The participants were asked to confirm the summary at the end of the conversation.

3.4 Statistical Analysis

To further understand stakeholder connection to each POS type on campus, statistical analysis was carried out. When Cronbach's alpha (α-value, table 3) was computed to evaluate the data's internal consistency, it came

out to be roughly 0.93. A Kruskal-Wallis test, a non-parametric method, along with a one-way ANOVA, were employed to determine significant differences in the importance and performance of each POS type.

To collect data, online and field surveys were both used. The perceived satisfaction and importance of POS have been investigated using the importance and performance analysis (IPA) approach. The POSs have been prioritized using computed differences between perceived importance and satisfaction. A post-occupancy evaluation (POE) and focus group discussion were also used to measure stakeholder satisfaction. Finally, non-parametric tests have been used to determine the substantial variation in importance and satisfaction as assessed by the stakeholders, have been employed. Therefore, the methods employed in this study offer significant potential for understanding the importance and performance levels of POS systems, providing a foundation for implementing effective strategies.

Table 3. Reliability Test - Cronbach's alpha values

Level	Indicators	α-value	Statistical Interpretation
Importance	Academic Purpose	0.927	Excellent ($0.9 \leq \alpha$)
Satisfaction	Academic Purpose	0.957	Excellent ($0.9 \leq \alpha$)
Importance	Recreation Purpose	0.928	Excellent ($0.9 \leq \alpha$)
Satisfaction	Recreation Purpose	0.941	Excellent ($0.9 \leq \alpha$)

III. RESULTS

1. VALUATION OF PUBLIC OPEN SPACES BY CAMPUS USERS

Due to their strong attachment and frequent use, the sixteen different types of point-of-sale systems were ranked as having the highest importance and satisfaction.
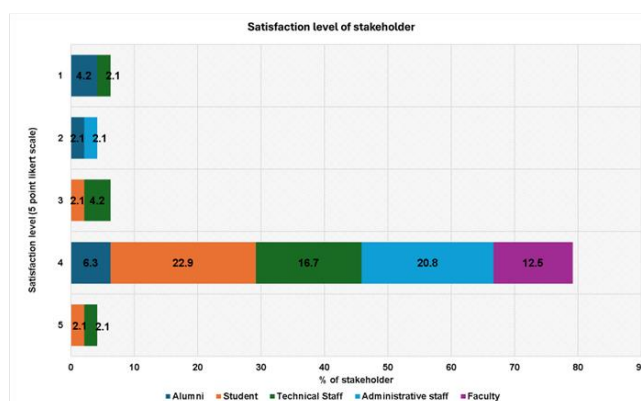

FIGURE 2. Satisfaction level of the stakeholders (5-point Likert scale).

These included bicycle tracks, walking tracks, sports fields, and maidan/multipurpose outdoor spaces. The chart (Figure 2) shows most stakeholders, particularly students (22.9%) and administrative staff (20.8%), are "Satisfied" with campus open spaces. However, "Extremely satisfied" responses are minimal (2.1% each for students and technical staff), indicating potential areas for enhancement. Notably, technical staff and alumni exhibit the highest levels of dissatisfaction and neutrality, with the overall POSs (Public Open Spaces) in the IIT Patna campus.

The perceived satisfaction and importance of each POS type for academic (Table 4) and recreational (table 5) purposes at IIT Patna campus is displayed in Figure 3 & 4. For the academic purpose, the mean value of overall satisfaction of the POSs in the campus on a five-point scale was found to be 2.87. Green spaces (A2) and sports fields/play fields (A13) are rated the highest in importance, with mean scores of 3.83 and 3.88, respectively. These areas are considered crucial for the academic environment, suggesting they are essential for

both relaxation and physical activity. Department corridors (A3) and courtyards (A4) also rank high in importance, emphasizing their role in daily academic activities. Satisfaction levels are highest for gardens (A1), green spaces (A2), and department corridors (A3), with mean scores of 2.94, 3.32, and 3.02, respectively. These rankings indicate that stakeholders are generally pleased with the maintenance and utility of these spaces. Conversely, department lawns (A5) and plazas in front of academic buildings (A6) rank lower in satisfaction, pointing to areas needing improvement. The rankings reveal some discrepancies. For instance, while green spaces (A2) and sports fields/play fields (A13) are highly important, their satisfaction ranks (2 and 5) suggest room for improvement. Conversely, department corridors (A3) show relatively high satisfaction despite lower importance, indicating effective maintenance but possible overinvestment.

Table 4. Importance and Satisfaction levels at academic purpose scale

Level	Indicators	Importance (Imp)			Satisfaction (Sat)		
		Mean	SD	Rank	Mean	SD	Rank
A1	Gardens	3.67	1.21	6	2.94	1.41	3
A2	Green spaces	3.83	1.21	6	3.02	1.41	2
A3	Department corridors	3.77	1.10	15	3.02	1.36	7
A4	Department courtyards	3.65	1.16	10	2.85	1.25	12
A5	Department lawns	3.52	1.03	16	2.88	1.28	10
A6	Plaza Infront of Academic building	3.21	1.27	4	2.56	1.24	14
A7	Plaza Infront of Administrative building	3.17	1.39	1	2.56	1.34	8
A8	Open spaces Infront of canteens	3.48	1.17	8	2.83	1.28	11
A9	Chowks/Squares/Informal nodes	3.02	1.28	3	2.67	1.24	13
A10	Bicycle trail	3.56	1.22	5	2.73	1.23	15
A11	Walking trail	3.56	1.11	13	2.88	1.38	5
A12	Water body	3.85	1.15	11	2.69	1.46	1
A13	Sports field/Play field	3.88	1.10	14	3.06	1.41	3
A14	Maidan/Multipurpose outdoor spaces	3.69	1.11	12	2.83	1.23	16
A15	Lookout spaces	3.52	1.17	8	2.69	1.37	6
A16	Vacant/unplanned/Unclassified spaces	3.27	1.32	2	2.54	1.30	9

Table 5. Importance and Satisfaction levels at recreational purpose scale

Level	Indicators	Importance (Imp)			Satisfaction (Sat)		
		Mean	SD	Rank	Mean	SD	Rank
A1	Gardens	4.17	0.95	15	2.92	1.33	12
A2	Green spaces	4.35	0.98	14	3.17	1.42	3
A3	Department corridors	3.88	1.10	9	2.98	1.31	14
A4	Department courtyards	3.79	1.24	5	2.83	1.23	16
A5	Department lawns	3.81	1.08	10	2.88	1.38	8
A6	Plaza Infront of Academic building	3.21	1.34	4	2.60	1.25	15
A7	Plaza Infront of Administrative building	3.00	1.37	2	2.60	1.35	11
A8	Open spaces Infront of canteens	3.83	1.15	7	2.94	1.41	4
A9	Chowks/Squares/Informal nodes	3.35	1.34	3	2.79	1.37	10
A10	Bicycle trail	3.94	1.12	8	2.88	1.33	13
A11	Walking trail	4.02	1.02	13	2.94	1.41	4
A12	Water body	4.25	1.02	12	2.65	1.54	1
A13	Sports field/Play field	4.48	0.90	16	3.33	1.39	6
A14	Maidan/Multipurpose outdoor spaces	4.19	1.07	11	3.08	1.43	2
A15	Lookout spaces	3.92	1.16	6	2.77	1.39	7

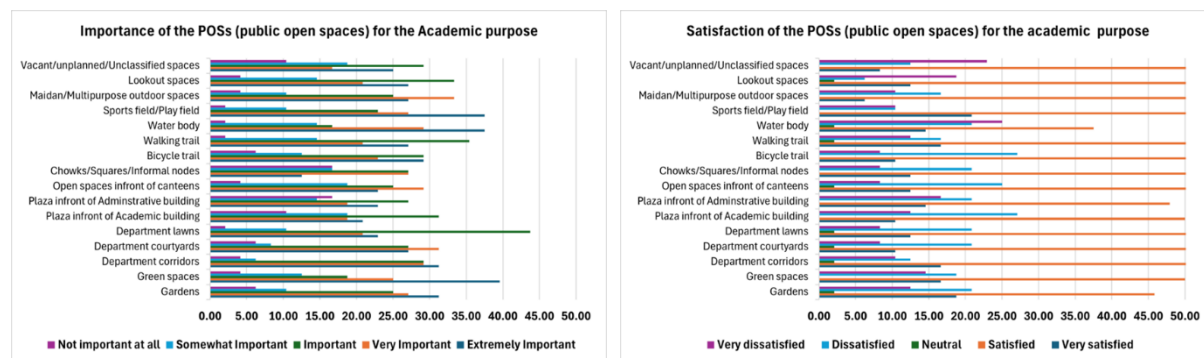| A16	Vacant/unplanned/Unclassified spaces	3.29	1.44	1	2.52	1.37	9

FIGURE 3. Distribution of importance and satisfaction (%) scores for the academic purpose, as perceived by stakeholders (based on 5-point Likert scale)
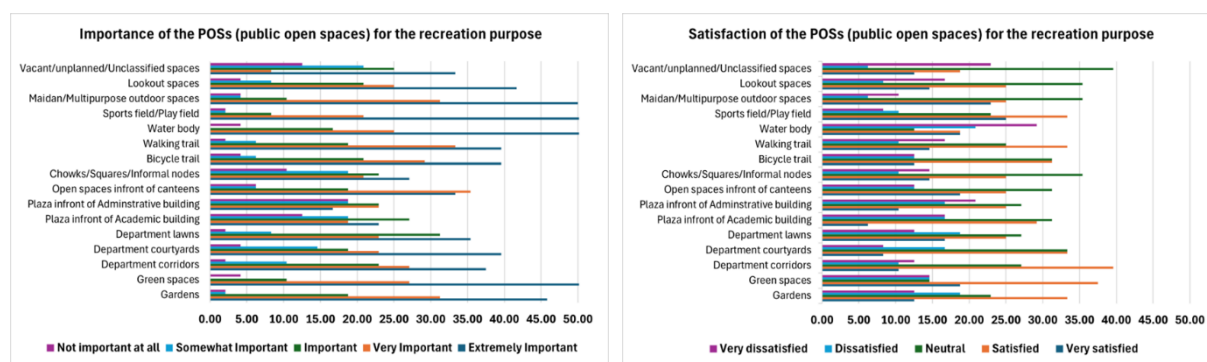

FIGURE 4. Distribution of importance and satisfaction (%) scores for the recreation purpose, as perceived by stakeholders (based on 5-point Likert scale)

On the other hand, for recreation purposes, green spaces (A2) and sports fields/play fields (A13) rank highest in importance, with mean scores of 4.35 and 4.48, respectively. These scores indicate that stakeholders place significant value on areas that promote physical activity and relaxation. Department corridors (A3) and department lawns (A5) also have high importance, emphasizing their critical role in the recreational environment. Satisfaction levels are highest for water bodies (A12), green spaces (A2), and maidan/multipurpose outdoor spaces (A14), with mean scores of 3.65, 3.17, and 3.43, respectively. These areas meet or exceed stakeholder expectations, reflecting effective maintenance and utility. However, department courtyards (A4) and plazas in front of academic buildings (A6) rank lower in satisfaction, pointing to a need for improvements. There are noticeable discrepancies between importance and satisfaction for several POS's. For instance, sports fields/play fields (A13) are ranked highest in importance but show a lower satisfaction ranking, suggesting that while these spaces are crucial, they may not be meeting stakeholder expectations. Conversely, green spaces (A2) have high importance and relatively high satisfaction, indicating effective maintenance. Therefore, it is evident from the overall research that appropriate management techniques are needed to improve the campus's open spaces system at IIT Patna.

2. DIFFERENCE IN THE IMPORTANCE AND SATISFACTION OF PUBLIC OPEN SPACE TYPES

It was noted that among all the POS types around the campus, the highest importance rating was awarded to Sports field/play field (4.31) followed by Green Spaces (4.10), Walking trails (4.07), Maidan/Multipurpose

outdoor spaces (4.03), bicycle trail (3.91), Department Courtyards (3.79), Water body (3.79), Open Spaces Infront of Canteens (3.71), Gardens (3.66), Department Corridors (3.57) and so on. The areas that stakeholders utilized the most frequently for exercise, study, social gatherings with friends, were sports fields/play fields, trails, maidans, green and open spaces, courtyards, and corridors which received the highest ratings. Conversely, though in terms of satisfaction Department Courtyards (3.60) were rated highly satisfied followed by Department Corridors (3.57), Plaza Infront of Administrative Building (3.51), Plaza Infront of Academic Building (3.49), Green Spaces (3.47), Sports field/play field (3.41), Open spaces Infront of Canteen (3.38), Gardens (3.32), Maidan/Multipurpose outdoor spaces (3.31) etc.

The statistical analysis revealed that while there are differences between the importance and satisfaction of POS types for recreational purposes, there are no significant differences between them for academic purposes. This indicates that stakeholders are evidently satisfied with the POSs on campus. According to the POE result, of the stakeholders who have used the POSs on campus, 27.94% are highly satisfied (5), 42.65% are very satisfied (4), 25% are satisfied (3), and 4.41% are dissatisfied (4).

3. *MEASURING DISCREPANCIES BETWEEN IMPORTANCE AND SATISFACTION*

Table 6 outlines the importance and satisfaction levels of various public open spaces (POSs) on a university campus for academic purposes, based on stakeholder perceptions. Gardens (A1) and green spaces (A2) have positive discrepancies (0.20), indicating stakeholders find them more satisfying than critical, suggesting effective maintenance. Department corridors (A3) show significant satisfaction despite lower importance, while department courtyards (A4) and lawns (A5) reflect good maintenance with room for slight improvements. Plazas in front of academic (A6) and administrative buildings (A7) show minor negative discrepancies (-0.03 and -0.05), highlighting the need for enhancements. Open spaces in front of canteens (A8) and informal nodes (A9) have small discrepancies, indicating adequate maintenance. Bicycle (A10) and walking trails (A11) show balanced or positive satisfaction, with the walking trail notably well-maintained. Water bodies (A12) and sports fields (A13) exhibit high satisfaction, suggesting their value is underappreciated. Maidan (A14) and lookout spaces (A15) reflect adequate maintenance. Vacant spaces (A16) have a negligible discrepancy (-0.01), indicating near-balanced expectations.

Table 6. Importance and Satisfaction levels at recreational purpose scale

Level	Indicators	Academic Purpose			Recreational Purpose		
		Imp	Sat	Discrepancy	Imp	Sat	Discrepancy
A1	Gardens	1.21	1.41	0.20	0.95	1.33	0.38
A2	Green spaces	1.21	1.41	0.20	0.98	1.42	0.44
A3	Department corridors	1.10	1.36	0.26	1.10	1.31	0.21
A4	Department courtyards	1.16	1.25	0.10	1.24	1.23	-0.01
A5	Department lawns	1.03	1.28	0.25	1.08	1.38	0.29
A6	Plaza Infront of Academic building	1.27	1.24	-0.03	1.34	1.25	-0.09
A7	Plaza Infront of Administrative building	1.39	1.34	-0.05	1.37	1.35	-0.02
A8	Open spaces Infront of canteens	1.17	1.28	0.11	1.15	1.41	0.25
A9	Chowks/Squares/Informal nodes	1.28	1.24	-0.04	1.34	1.37	0.02
A10	Bicycle trail	1.22	1.23	0.01	1.12	1.33	0.21
A11	Walking trail	1.11	1.38	0.27	1.02	1.41	0.38
A12	Water body	1.15	1.46	0.31	1.02	1.54	0.52
A13	Sports field/Play field	1.10	1.41	0.30	0.90	1.39	0.49
A14	Maidan/Multipurpose outdoor spaces	1.11	1.23	0.11	1.07	1.43	0.36
A15	Lookout spaces	1.17	1.37	0.20	1.16	1.39	0.22
A16	Vacant/unplanned/Unclassified spaces	1.32	1.30	-0.01	1.44	1.37	-0.08

On the other hand, for recreation purposes, Table 7 indicates that Gardens (A1) and green spaces (A2) have high positive discrepancies (0.38 & 0.44), with satisfaction significantly exceeding importance, indicating

excellent maintenance and stakeholder appreciation. Department corridors (A3) and lawns also show positive discrepancies, though less pronounced. In contrast, department courtyards (A4) and plazas in front of academic (A6) and administrative buildings (A7) have slight negative discrepancies (-0.01, -0.09 and -0.02), suggesting these areas could benefit from minor improvements to meet stakeholder expectations better.

Open spaces in front of canteens (A8), bicycle (A10) and walking trails (11), water bodies (A12), sports fields (A13), and multipurpose outdoor spaces (A14) all show positive discrepancies, reflecting high satisfaction levels. Particularly, water bodies and sports fields (A13) stand out with the highest positive discrepancies (0.49), indicating exceptional satisfaction. Conversely, vacant and unclassified spaces fields (A16), have a slight negative discrepancy (-0.08), suggesting a need for minor enhancements. Overall, the majority of POSs meet or exceed stakeholder expectations, with a focus on enhancing areas with minor negative discrepancies to maintain high satisfaction levels and enrich the campus recreational environment.

4. MAPPING OF IMPORTANCE-PERFORMANCE ANALYSIS AND PRIORITIZATION OF PUBLIC OPEN SPACE TYPES

1.1 Quadrangle -I: High Importance - Low Satisfaction (Concentrate Here):

For recreation purposes, Figure 6 indicates that Water body (A12) is highly important but has low satisfaction scores, suggesting that improvements are needed. Prioritizing enhancements in this area could significantly boost overall stakeholder satisfaction. Water body (A12) and Lookout spaces (A15) are important but have low satisfaction scores, indicating a need for focused improvements. Addressing issues in these areas could enhance their utility and satisfaction.

1.2 Quadrangle -II: High Importance - High Satisfaction (Keep Up the Good Work):

For recreation purposes, figure 6 indicates that green spaces (A2) and Sports field/Play field (A13) are highly important and highly satisfying, indicating they are well-maintained and meet stakeholders' needs effectively. On the other hand, for academic purposes, Gardens(A1), Green spaces (A2), Department corridors(A3) and Sports field/Play field (A13) are both highly important and highly satisfying. Maintaining the quality of these spaces should be a priority as they are key to stakeholders' academic experience.
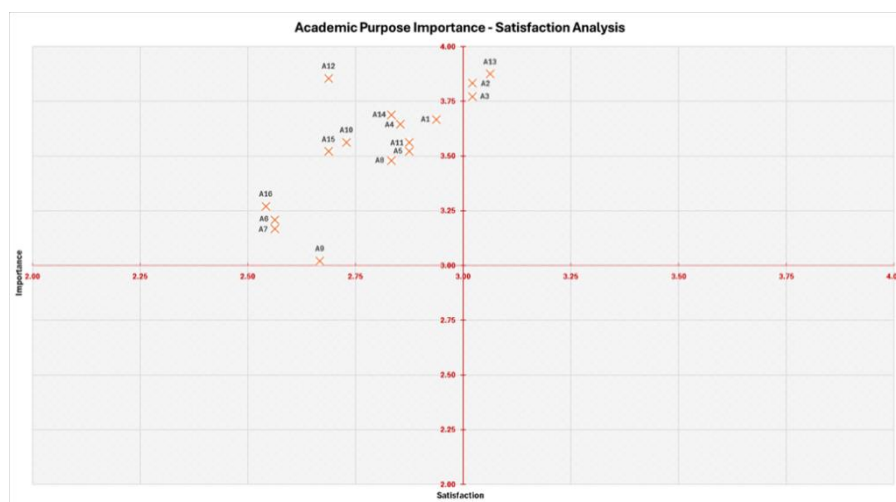

FIGURE 5. Importance and satisfaction for academic purpose

1.3 Quadrangle -III: Low Importance - Low Satisfaction (Low Priority):

For the recreation and academic purposes, figure 5 & 6 indicates that Plaza Infront of Academic building (A6), Plaza Infront of Administrative building (A7), Chowks/Squares/Informal nodes (A9), and Vacant/unplanned/Unclassified spaces (A16) have low importance and low satisfaction, suggesting they are

not critical to stakeholders. Improvements here should be a lower priority compared to more important and underperforming spaces.

1.4 Quadrangle -IV: Low Importance - High Satisfaction (Possible Overkill):

For the recreation and academic purposes, Figure 5 and Figure 6 indicates that Department corridors (A3), and Maidan/Multipurpose outdoor spaces (A14) are less important but have high satisfaction scores, indicating that while they are performing well, resources might be better allocated elsewhere. On the other hand, for academic purposes, Bicycle trail (A10), Walking trail (A11) and Maidan/Multipurpose outdoor spaces (A14) are less important but receive high satisfaction scores.
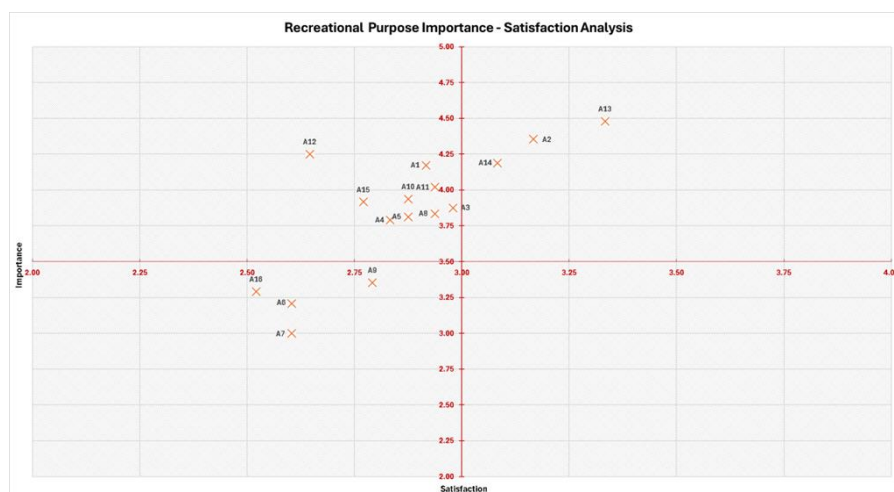

FIGURE 6. Importance and satisfaction for recreation purpose

1.5 Prioritization

For recreational purposes, the priority should be on improving the highly important but low satisfaction areas, particularly Water body (A12). Maintaining high satisfaction in key areas like green spaces (A2) and Sports field/Play field (A13) are also crucial. For academic purposes, efforts should focus on enhancing Water body (A12) and Lookout spaces (A15) to align satisfaction levels with their importance. Ensuring that high importance and high satisfaction areas Gardens(A1), Green spaces (A2), Department corridors(A3) and Sports field/Play field (A13) continue to meet stakeholder expectations is vital.

IV.   DISCUSSION

The analysis of stakeholder satisfaction with public open spaces (POS) on a university campus unveils a multifaceted landscape of perceptions and experiences. There is a beneficial correlation between public open spaces and enhancements in physical, mental, and social health, as well as overall well-being outcomes [23, 24]. It was noted that among all the POS types around the campus, the highest importance rating was awarded to the Sports field/playfield (4.31) followed by Green Spaces (4.10), Walking trails (4.07), Maidan/Multipurpose outdoor spaces (4.03) and bicycle trail (3.91). Numerous previous research studies have reported a consistent pattern of activities[63, 64]. Although the overall satisfaction is high, particularly among students and administrative staff, notable pockets of dissatisfaction and neutrality exist, especially among alumni and technical staff. These findings suggest that while the campus has successfully maintained many of its open spaces, certain areas demand targeted attention and improvement.

1. Implications of Findings

The discrepancies between the importance and satisfaction levels of various POS highlight the necessity for strategic interventions. For instance, the high satisfaction with gardens (A1) and green spaces (A2), despite their lower perceived importance, suggests these areas are well-maintained but possibly underutilized. Such a unique finding where pockets have low importance and yet high satisfaction value has not been previously seen in other studies. Conversely, the slight negative discrepancies in plazas (A6, A7) and informal nodes (A9) indicate these critical engagement spaces are not meeting stakeholder expectations, necessitating enhancements in their maintenance and functionality. A similar study in Saudi Arabia shows a substantial lack of national strategies for the effective planning of POSs [65].

These findings have significant implications for policy and practice in campus planning. They underscore the importance of understanding the nuanced needs and preferences of different stakeholder groups to inform the development and management of POS effectively. By addressing these discrepancies, universities can enhance the overall campus experience, promoting both educational and recreational benefits.

2. *Informing Policy and Practice*

- *Targeted Interventions for Specific Groups:* A detailed analysis of the specific concerns of alumni and technical staff is imperative. These groups exhibit higher levels of dissatisfaction and neutrality, suggesting their unique needs are not being adequately met. Tailored strategies should be developed to address these concerns, ensuring a more inclusive approach to POS management.
- *Enhancing Critical Engagement Spaces:* Improving plazas (A6, A7) and informal nodes (A9) should be prioritized, as these spaces are essential for stakeholder engagement but currently fall short of expectations. Regular maintenance schedules and aesthetic upgrades can significantly enhance their appeal and functionality.
- *Promoting Utilization of Underutilized Spaces:* Despite high satisfaction, gardens (A1) and green spaces (A2) are perceived as less important, indicating potential underutilization. Initiatives to promote their use, such as hosting campus events and integrating amenities like seating, lighting, and recreational facilities, can elevate their importance and engagement.
- *Integrating POS into Educational Strategies:* POS can be seamlessly integrated into educational strategies by creating outdoor classrooms, study areas, and spaces for experiential learning. This integration can enrich the academic experience, fostering a deeper connection with the natural environment and promoting innovative teaching methods.
- *Environmental and Sustainability Initiatives:* Enhancing POS also aligns with environmental and sustainability goals. Developing green spaces and maintaining gardens contribute to biodiversity, improve air quality, and create a sustainable campus environment. Policies should prioritize eco-friendly practices in the development and maintenance of these spaces.
- *Continuous Feedback Mechanism:* Implementing a robust feedback mechanism where stakeholders can continuously provide input on POS will enable real-time improvements and ensure the spaces evolve to meet changing needs and preferences. This dynamic approach fosters a sense of ownership among stakeholders and promotes ongoing engagement.

V. CONCLUSION

The purpose of this study was to identify gaps between perceived importance and actual performance, providing valuable insights for developing effective planning strategies. Sixteen types of public open spaces (POS) were selected for the questionnaire based on the university's landscape. Performance was evaluated using a 5-point Likert scale, ranging from strongly disagree to strongly agree. Participants were also asked to rate the importance and satisfaction of each of the sixteen POS for recreational and academic purposes at the IIT Patna campus. This was done to assess the significance and user satisfaction of different POS among stakeholders. The study examined the effectiveness and relevance of various POS types and evaluated the level of satisfaction among the campus's social groups that utilize these spaces.

This research draws a picture of general satisfaction in public open spaces on the university campus and follows up on specific areas that can be further enhanced. This study highlights the importance of well-maintained public open spaces in enhancing the quality of life for stakeholders on the IIT Patna campus. While

certain areas such as gardens and green spaces are highly valued and well-maintained, others like plazas and informal nodes require improvements. Effective management and strategic planning are essential to address these discrepancies and ensure the sustainability and utility of campus POS. Future research should explore longitudinal impacts and broader stakeholder engagement to further enhance campus planning.

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Author contribution

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Data Availability Statement

Data are available from the authors upon request.

Conflict of interest

The authors have no potential conflicts of interest, or such divergences linked with this research study.

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