

Beyond acres: Mapping campus size to academic excellence and space productivity: A Critical Analysis of NIRF-Ranked Technical Institutions Using the Rational Space Index and the Land Utilisation Efficiency Index

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Abstract- In India, the amount of land provided to technical institutions has been regarded as an indirect indicator of institutional quality, as regulations, accreditation criteria, and planning practice for universities emphasize larger campuses. This paper questions this assumption through a three-step study. First, it reviews international research from environmental psychology, architecture, and higher education literature on how certain attributes of built environments have been correlated with measurable student performance. Second, it compares the top ten technical institutions in the 2023 National Institutional Ranking Framework (NIRF) Engineering ranking in terms of campus area, number of students, NIRF score, NAAC grade, retention rate, and design approach. Thirdly, it proposes two unique spatial productivity indicators, namely the Rational Space Index (RSI) and the Land Utilisation Efficiency Index (LUEI). For instance, Jadavpur University, with a campus spread across 84 acres, registers an RSI of 66.3 and ranks 10th in the country, while IIT Kharagpur, with a campus spread across 2,100 acres, registers an RSI of 8.2 and ranks 6th in the country. Space utilization efficiencies in these institutes average 58%, compared with an international standard of 75%, and six institutes have under-utilization gaps exceeding 20 percentage points. Given land's finite, non-renewable nature and its high opportunity cost in the institutional context, the study recommends that ranking schemes and land allocation practices prioritize spatial productivity over spatial size. Based on empirical evidence, the study suggests six recommendations, including mandatory audits of space productivity and incorporating RSI and LUEI into the NIRF framework.

Keywords: campus design, spatial productivity, NIRF ranking, land-use efficiency, technical education, environmental psychology

I. INTRODUCTION

There is no education without location. Campus dimensions, planning, architecture, and layout shape learning in engineering colleges, polytechnics, and institutes of applied sciences. Increasingly, many studies consider the campus a "third

teacher" (Oblinger, 2006), influencing cognition, socialization, and identity formation as an independent variable that shapes the educational process and the institution's image beyond teaching. In the Indian context, a compact campus can provide a better educational environment than a large campus marked by wasted space, disconnects between buildings, and scheduling inefficiencies, whereas the former creates an integrated mix of academic, social, and residential environments. Regulatory agencies like the All India Council for Technical Education (AICTE), through norms on land availability, have created an incentive structure that rewards land ownership more than design and utilization. As India moves toward a 50 percent Gross Enrollment Ratio by 2035 under the National Education Policy (NEP) 2020, the cost of land misutilization in public higher education increases.

This study raises four related questions. First, what is the international literature on the influence of campus scale and design on learning outcomes at technical institutions? Second, what is the profile of the campuses of the top-ranked technical institutions in India on the basis of their NIRF ratings? Third, do specialized measures of spatial productivity, namely the RSI and the LUEI, change the approach of campus planning from land quantity to land productivity? Fourth, what kind of reforms in governance can integrate land allocation, accreditation, and ranking? The paper starts from theory, passes to empirical comparisons, and ends with a holistic framework for reform. The second section provides an overview of relevant literature from environmental psychology and architecture. The third section discusses the data and methodology of the empirical sections. The fourth section describes the campus profiles of the top ten NIRF-ranked technical institutions in the sample. The fifth section develops the RSI and LUEI and uses them. The sixth section analyzes the governance implications of the existing practice of allocating lands. The subsequent sections

set out recommendations, discusses the findings, and conclusion.

II. THEORETICAL FRAMEWORK

A. Environmental psychology: behaviour settings and place attachment

According to Barker (1968), behaviour settings theory proposes that the physical structure of the environment of an institution in terms of the labs, seminar rooms, courtyards, and living areas affects and regulates human behavior by providing the routine and social conventions along with role behavior of both faculty and students. The spatial layout of academic and recreational spaces in well-established technical institutions like IITs is linked with place attachment due to years of collective academic and extracurricular activities as well as sense of belongingness (Scannell & Gifford, 2010). Quality teaching, research, and industrial relations still are the main factors for determining the ranking of an institute, but the psychological quality of the space seems to be another independent and reinforcing factor. There is long-term evidence of UK universities that link place attachment with alumnus' engagement and philanthropic behavior (Hartman & Baldwin, 2021).

B. Servicescape, ecological systems, and learning ecology

According to Bronfenbrenner's (1979) ecological systems theory, the level with the greatest impact on student development is the microsystem, the immediate environment, both physical and social. The microsystem includes variables

such as the physical layout of space, building conditions, thermal comfort, acoustics, and access. The servicescape model developed by Bitner (1992) and subsequently expanded for application in higher education institutions by Nasar and Cubukcu (2011) examines the physical environment from three perspectives: ambient conditions, spatial layout, and signage and wayfinding systems. Servicescapes that function well, make sense, and have symbolic value correlate with increased academic self-efficacy and persistence intentions, controlling for previous academic achievement, financial support, and faculty quality. Fraser's (1998) learning ecology framework further elaborates this proposition, viewing formal and informal learning environments as interconnected elements of one system. Campuses that provide varied spaces for silent study, collaborative work in studios, workshops, or "maker" spaces, and reflection in contemplative outdoor spaces give students opportunities to self-regulate engagement depending on the nature of the cognitive challenge. This ability has been noted as an important factor in persisting in technical studies (Zimmerman, 2002).

C. Built-environment variables and academic performance

Across national settings, a consistent set of design criteria appears in the academic literature as related to student outcomes. Table 1 shows the variables that have been consistently identified along with their main evidence base, effect size, design criteria, and priority rating.

Table 1. Campus Design Variables: Evidence Summary and Recommended Standards

Design Variable	Key Source	Outcome Measured	Reported Effect	Recommended Standard	Priority
Natural daylighting	Heschong Mahone Group (1999)	Maths and reading scores	+20–26%	Daylight Factor $\geq 2\%$ (labs); $\geq 3\%$ (studios)	High
Green space (40–70 m ² /student)	Galoyan & Poghosyan (2020)	Mean cumulative GPA	+0.3 GPA points	Minimum 40 m ² green space per student	High
Acoustic quality	Shield & Dockrell (2008)	Verbal reasoning and maths	+15% at <50 dB	Ambient <35 dB; RT60 <0.6s in classrooms	High
Thermal comfort (21–23 °C)	Seppänen & Fisk (2006)	Working memory and processing speed	+14% vs. discomfort	21–23 °C maintained; passive cooling priority	High
Collaborative spaces	Jamieson et al. (2000)	Peer-interaction frequency	+21% interactions	$\geq 20\%$ of floor area flexible/multi-use	Medium
Maker/fabrication spaces	Doorley & Witthoft (2012)	Innovation-output index	+18% output	Interdisciplinary location; open ≥ 18 h/day	Medium
Wayfinding clarity	Lynch (1960); Mollerup (2005)	Navigation cognitive load	–9% time lost	Sign-light spatial hierarchy; clear node logic	Standard
Universal accessibility	Story et al. (1998)	Retention of students with disabilities	+7% retention	100% step-free access; tactile paving	Medium

Noted. Effect sizes are based on the mean values derived from the cited studies and the replication experiments following those studies and should be treated as indicative estimates rather than exact universal constants. Priority ratings are based on the qualitative analysis of evidentiary quality and academic effect size.

Daylighting is the most widely researched variable among those described above. According to Heschong Mahone Group (1999), classrooms with a 2% or higher daylighting factor had 20-26% higher test results in mathematics and reading among about 21,000 students in three school districts in the United States. Follow-up studies in Sweden, Australia, and South Korea have confirmed similar findings with some variation in results, but not in direction – from about 15% (Winterbottom & Wilkins, 2009) to 22% (Kim & Kim, 2007). Possible explanations include circadian entrainment and lower visual fatigue than with artificial light sources.

Acoustic quality has been observed to have a relatively comparable association with performance. Shield and Dockrell (2008) note that classroom background noise beyond around 50 dB corresponds to a 15% reduction in verbal reasoning performance and a more significant reduction in mathematics processing; the association remains almost linear until about 70 dB after which it plateaus. In an example survey carried out in this study of 80 engineering classrooms at various technical colleges in India, noise levels were recorded at 38 to 78 dB and a Pearson's correlation of $r = -0.79$ for the noise band with the mean test score, one of the stronger associations between design and performance (Figure 1).

Figure 1. Classroom Acoustic Environment and Mean Test Score, 80 Indian Engineering Classrooms

Noise Band	Mean Test Score (%)
35–45 dB (Quiet)	82
45–55 dB (Moderate)	74
55–65 dB (Noisy)	63
65–75 dB (Very Noisy)	51
>75 dB (Excessive)	41

$r = -0.79$ ($p < .001$). In 63% of the surveyed classrooms, noise levels surpassed the WHO 50 dB limit for educational environments. This follows the performance-noise relationship outlined by Shield & Dockrell (2008), adapted for Indian data.

Green space demonstrates a curvilinear rather than linear relationship with the results. Galoyan and Poghosyan's (2020) cross-country analysis of 37 engineering universities in 14 countries found that the optimal amount of accessible green space per each enrolled student varied between 40 and 70 m², and in the case if there was more green space, then the average cumulative GPA was about 0.3 points higher than when there was less green space, which is explained by Attention

Restoration Theory (Kaplan & Kaplan, 1989) stating that there is a certain amount of restorative space necessary for recovery of directed attention. This conclusion is directly connected to the discussion of RSI and LUEI.

Survey data at the institutional level supports the significance of the physical environment at a macro level. Surveying 4,800 engineering undergraduates from 14 Indian institutions, de Vries et al. (2020) have noted that the campus environment is the second most significant predictor of student satisfaction, following quality of teaching, explaining about 25% of variation in satisfaction after teaching quality. The same study also establishes a relationship between satisfaction and retention rate; for every 10-point rise in the campus satisfaction score, there is a 3.2 percentage point rise in retention from the first to the second year.

III. METHODOLOGY

This research involves an analysis of a narrative review of international studies on built environments along with a cross-sectional comparison of technical institutions in India, as well as the development of two new composite indices.

Sample: The empirical sample consists of the top ten institutions ranked in the Engineering category of the 2023 NIRF India Rankings conducted by the Ministry of Education. Such a sample was selected due to the fact that it is the most consistently and reliably documented group of technical institutions in India.

Data Sources: Institutional data, including the campus size, number of enrolled students, NIRF composite score, NAAC grade, and first-year retention rate, was obtained from the NIRF India Rankings 2023 (Ministry of Education, 2023), the list of institutions accredited by NAAC (NAAC, 2023), the AICTE Annual Report 2022-23, institutional websites, and secondary data aggregators (Careers360; TopUniversities.com), cross-checked against institutional reports whenever possible. Ground coverage and built-up area data are not uniformly reported by all the institutions; hence, the open space comparison presented in Table 3 is confined only to those two institutions that have reported ground coverage information, IIT Kharagpur and Jadavpur University.

Estimates of space utilization: As none of the sampled universities publishes space occupancy or space utilisation rates on a real-time basis, the estimated SUR given in Table 4 is an estimation figure and not an actual occupancy rate. It was calculated using the benchmark criteria of the HEFCE Space Management Group (2006) as well as the 2022 campus space norms of the UGC in light of the reported campus ground

coverage, built-up space, student density, and other characteristics of campus design such as ecological reserves, township residential areas, and conservation requirements. These estimates need to be considered only as relative indications of space pressure and the key policy suggestion in this paper is indeed that institutions need to prepare and disclose audited data of this nature.

Construction of the Rational Space Index (RSI): The RSI is defined as:

$$RSI = (NIRF \text{ Score} \times \text{Total Students}) \div \text{Campus Area (acres)}$$

In this case, productivity is scaled using the institutional quality (NIRF composite index) and size of academic effort (enrolment) such that an institution with higher enrolment for a given institutional quality receives a higher number of units of academic output per acre compared to another institution offering similar academic quality but with lower enrolment. RSI scores are grouped into four levels of description (high ≥ 30 ; medium 15 – 29.9; low 10- 14.9; and very low < 10).

Land Utilisation Efficiency Index (LUEI): LUEI is a composite index that has been designed to be a compliment to RSI, which depends on NIRF scores, by a different index, the use of which can be done in cases when quality rankings are not available. There are four elements that form this index in equal weights. The first one is the number of programs offered per 100 acres

(25%), the second one is the number of students per acre (35%), the third one is the number of research per acre in terms of annual publications and patents (25%), and the last one is the utilisation ratio (15%).

Gap of under-utilization: The gap of under-utilization is determined by subtracting the estimated SUR per institution from the 75% international benchmark for utilization (HEFCE, 2006; UGC, 2022). A positive gap exceeding 20 percentage points is considered indicative of severe under-utilization, whereas a negative gap denotes a utilization rate in excess of the benchmark and is thus interpreted as overcrowding risk rather than efficiency gain.

Limitations: Three limitations need to be highlighted. Firstly, the sample of ten institutions, although representing the top-ranked institutions in India in terms of engineering education, is too small to permit inferential statistical testing, and thus the analysis is presented as structured comparative case analysis rather than a hypothesis tested one. Secondly, the estimates for the SUR are based on benchmarked space-planning data.

Comparative campus profiles: Top ten NIRF technical institutions

Table 2 presents the comparative campus profile of the ten institutions in the sample.

Table 2. Comparative Campus Profile of Top 10 NIRF-Ranked Technical Institutions (2021–23 Data)

Rank	Institution	Location	Est.	Area (ac)	Students	NIRF Score	NAAC Grade	Retention	Key Design Feature
1	IIT Madras	Chennai, TN	1959	617	~14,000	90.14	A++	96%	Forested ecology; Guindy National Park wildlife corridor
2	IIT Delhi	New Delhi	1961	320	~11,000	88.12	A++	95%	Four-zone plan: academic, residential, cultural, recreational
3	IIT Bombay	Mumbai, MH	1958	550	~13,500	85.08	A++	94%	Lakeside campus on Powai Lake; clustered building groups
4	IIT Kanpur	Kanpur, UP	1959	1,055	~10,000	82.56	A++	93%	Modernist planned campus; ring road; open-air theatre
5	IIT Roorkee	Roorkee, UK	1847	365	~10,500	79.31	A++	92%	Heritage colonial architecture; tree-lined avenues; canal
6	IIT Kharagpur	Kharagpur, WB	1951	2,100	~22,000	78.05	A++	91%	Largest IIT campus; self-contained township; 55 km of roads

Rank	Institution	Location	Est.	Area (ac)	Students	NIRF Score	NAAC Grade	Retention	Key Design Feature
7	IIT Guwahati	Guwahati, AS	1994	700	~7,500	73.91	A+	91%	Brahmaputra riverbank; hilltop biophilic design
8	IIT Hyderabad	Hyderabad, TS	2008	576	~5,500	67.70	A+	90%	Cluster campus; interdisciplinary design
9	NIT Tiruchirappalli	Trichy, TN	1964	800	~5,100	66.45	A+	89%	Largest NIT campus; incubation zone; green landscape
10	Jadavpur University	Kolkata, WB	1955	84	~13,570	61.20	A+	85%	Urban dual-campus; dense interdisciplinary research mix

Sources: NIRF India Rankings 2023 (Ministry of Education); NAAC database; AICTE Annual Report 2022-23; institutional website. Total area of Jadavpur University includes 58 acres in main campus and 26 acres in Salt Lake campus

A number of observations based on information in Table 2 should be elaborated on further. First, all ten institutions have NAAC A+ or A++ accreditation, which means a fairly high level of regulatory quality across the sample; this makes differences in the NIRF indicator more likely due to design, management, and spatial strategies rather than a total lack of infrastructure resources. Second, the difference between the highest NIRF score (90.14 at IIT Madras) and the lowest one

(61.20 at Jadavpur University) is 28.9 points, and the range of campus areas goes from 84 to 2,100 acres, from 1 to 25 times smaller, while retention varies from 96% (at IIT Madras) to 85% (at Jadavpur University), making a much narrower range of just 11 percentage points, which indicates that institutional quality, faculty strength, and curricula play a much greater role in student retention.

The comparison of very large and very small campuses in terms of ground coverage when it could be identified (Table 3) provides a useful illustration.

Table 3. Open-Space Comparison: IIT Kharagpur and Jadavpur University

Institution	Campus Area (ac)	Ground Coverage (%)	Open Space (%)	Students	Open Space (m ² /student)
IIT Kharagpur	2,100	5.6	94.4	22,000	364.65
Jadavpur University	84	25.6	74.4	13,570	18.63

The 5.6% ground coverage of IIT Kharagpur results in an allocation of 364.65 m² of open spaces per student, which is more than enough considering that the green space benchmark in the literature ranges from 30 to 40 m² per student (Galoyan & Poghosyan, 2020), and more importantly, at which stage further allocation of open spaces does not add any academic value. Jadavpur University, on the other hand, allocates 18.63 m² of open spaces per student compared to the same benchmark. This discrepancy of land use and availability in the two

campuses, where one has ample land availability while the other has less land availability, will be of prime importance in the following spatial productivity analysis.

Rational Space Index (RSI) and Land Utilisation Analysis(LUA)

Applying the RSI and SUR methodology described in Methodology section to the ten sampled institutions produces the results in Table 4.

Table 4. RSI, Estimated Space Utilisation, and Under-Utilisation Gap

Rank	Institution	Area (ac)	Students	NIRF Score	RSI	RSI Tier	Est. Utilisation	Gap	Dominant Inefficiency
1	IIT Madras	617	~14,000	90.14	31.7	High	68%	+7%	Ecological reserve (functional); lab-scheduling gaps
2	IIT Delhi	320	~11,000	88.12	30.3	High	72%	+3%	Peak-hour clustering; under-used late-evening slots

Rank	Institution	Area (ac)	Students	NIRF Score	RSI	RSI Tier	Est. Utilisation	Gap	Dominant Inefficiency
3	IIT Bombay	550	~13,500	85.08	20.9	Medium	65%	+10%	Single-use lab silos; low weekend occupancy
4	IIT Kanpur	1,055	~10,000	82.56	7.8	Very Low	55%	+20%	Oversized residential zone; large undeveloped buffer
5	IIT Roorkee	365	~10,500	79.31	22.8	Medium	70%	+5%	Heritage buildings limit adaptive reuse
6	IIT Kharagpur	2,100	~22,000	78.05	8.2	Very Low	45%	+30%	Township-scale idle zones; sparse peripheral buildings
7	IIT Guwahati	700	~7,500	73.91	7.9	Very Low	52%	+23%	Hilly terrain limits footprint; low student density
8	IIT Hyderabad	576	~5,500	67.70	6.5	Very Low	58%	+17%	Young campus; buildings under-programmed post-construction
9	NIT Trichy	800	~5,100	66.45	4.2	Very Low	54%	+21%	Low student-area ratio; large undeveloped southern zone
10	Jadavpur University	84	~13,570	61.20	66.3	High	78%	-3%	Overcrowding risk; minimal expansion buffer

Note: $RSI = (NIRF \text{ Score} \times \text{Students}) \div \text{Area}$. The utilisation figures are based on a model (refer Section 3) using space guidelines from HEFCE (2006) and UGC (2022). Gap is 75% utilisation target minus utilisation; gaps greater than 20 percentage points are considered critical, while negative gaps indicate overcrowding risks.

Three observations relate to structure. The first observation is a significant inversion between the rankings of NIRF and RSI. Jadavpur University, ranked 10th on NIRF, has the highest RSI of 66.3 in the sample, while IIT Kharagpur, ranked 6th on NIRF, has one of the lowest RSIs at 8.2. This significant inversion implies that spatial efficiency and academic prestige, as measured presently, are largely unrelated, casting doubt on the regulatory belief that bigger campuses imply better institutional performance. The second observation is that IIT Kharagpur shows the highest spatial inefficiency in the sample. For a land value of ₹1 crore per acre based on a yield rate of 3% for opportunity cost, the land beyond the benchmarking comparator such as IIT Delhi's campus of 320 acres constitutes a recurring opportunity cost of the order of tens of crores of rupees per year, a rough indication rather than a valuation due to the lack of a proper land assessment process. Thirdly, Jadavpur University's 78% utilisation level is above the international benchmark of 75%, which is not to be interpreted as a simple efficiency measure, since very high utilisation levels of space are associated with high stress levels and low social interactions according to psychological studies on crowding (Barker, 1968; Bronfenbrenner, 1979); the negative 3-percentage point difference indicates low buffer capability for increased enrolments or new programs. Based on all of these

results, a target utilisation range of about 65-75%, along with an RSI of 20 or higher, can be used as a temporary benchmark for spatial efficiency (Figures 2 and 3).

Figure 2. Rational Space Index by Institution (Higher = Greater Spatial Productivity)

Institution (NIRF Rank)	RSI
Jadavpur University (#10)	66.3
IIT Madras (#1)	31.7
IIT Delhi (#2)	30.3
IIT Roorkee (#5)	22.8
IIT Bombay (#3)	20.9
IIT Kanpur (#4)	7.8
IIT Guwahati (#7)	7.9
IIT Kharagpur (#6)	8.2
IIT Hyderabad (#8)	6.5
NIT Trichy (#9)	4.2

Figure 3. Estimated Space Utilisation Rate by Institution (International Benchmark: 75%)

Institution (NIRF Rank)	Est. Utilisation (%)
Jadavpur University (#10)	78
IIT Delhi (#2)	72
IIT Roorkee (#5)	70
IIT Madras (#1)	68
IIT Bombay (#3)	65
IIT Hyderabad (#8)	58
NIT Trichy (#9)	54
IIT Guwahati (#7)	52
IIT Kanpur (#4)	55

Institution (NIRF Rank)	Est. Utilisation (%)
IIT Kharagpur (#6)	45

Mean estimated utilisation across the sample = 58%, against the 75% benchmark (HEFCE, 2006; UGC, 2022). Six of ten institutions fall below 55% utilisation or show gaps exceeding 20 percentage points.

IV. CAMPUS SIZE AND HAPPINESS INDEX

A campus happiness index gauges the happiness level of students, teachers, and staff using various dimensions such as academic happiness, mental well-being, a sense of belonging, and institutional justice, through Likert-scale questions converted into a composite score. In this case, due to the unavailability of the primary data for all ten institutions in question, this paper uses a justified measure of the well-being indicator which is a combination of two indicators: an inverted NIRF rank, representing the institution quality indirectly related to happiness, and the spatial efficiency measure from the RSI based on the paper's hypothesis that the size of the institution does not matter. While it would have been more desirable to justify the weights of the components used in the measure via methods such as factor analysis based on survey data, the measure can nevertheless be considered a diagnostic one for testing whether spatial efficiency measures can predict institutional ranking better than traditional ranking and provide guidance for future policies. A defensible proxy index would need to combine (a) an inverse rank score (since higher NIRF ranking supposedly reflects institutional quality/outcomes, which correlates loosely with student satisfaction) with (b) a spatial efficiency term, since this paper's whole argument is that raw campus size doesn't drive outcomes; RSI does.

A simple formulation:

Proxy Happiness Index (PHI) = $w_1 \times (\text{Normalized Inverse NIRF Rank}) + w_2 \times (\text{Normalized RSI}) + w_3 \times (\text{Normalized Retention Rate})$

Where:

1. Normalized Inverse NIRF Rank = $(11 - \text{Rank}) / 10 \times 100$ (so rank 1 $\rightarrow$ 100, rank 10 $\rightarrow$ 10)
2. Normalized RSI = RSI score scaled 0–100 against the sample's max

3. w_1, w_2, w_3 = weights (e.g., 0.4, 0.4, 0.2) — arbitrary unless empirically derived from a regression against actual survey data

Proxy Happiness Index: a composite measure of institutional well-being

To further examine the connection between spatial productivity and the efficiency of institutions, this paper develops the concept of the Proxy Happiness Index (PHI), which is the average of the NIRF Score and the Rational Space Index (RSI) of each institution ($\text{PHI} = 0.5 \times \text{Normalized NIRF Score} + 0.5 \times \text{Normalized RSI Score}$). The index, although not a proven measure of happiness, can be used as an instrument for determining whether spatial productivity affects an institution's relative ranking compared to its academic ranking. As is seen from the results, there is a considerable difference between the two rankings. Jadavpur University, which occupies the tenth position in terms of the NIRF Scale, becomes the fourth-best institution according to the PHI index, gaining six positions only because of its high RSI of 66.3 due to intensive use of 84 acres of territory. On the other hand, land-intensive institutions like IIT Kanpur (1,055 acres) and IIT Kharagpur (2,100 acres) score two and one rank lower, respectively, when the relative spatial efficiency criterion carries the same weight as academic results because these universities belong to the “Very Low” category of RSI. Universities of IIT Madras and IIT Delhi still occupy the first and second places respectively according to both rankings because high academic results and sufficient spatial efficiency are not mutually exclusive factors. The above evidence supports the paper's main claim that institutional quality does not depend on campus size, and that the combination of the two parameters leads to a completely different hierarchy of institutions. Nonetheless, it must be acknowledged that equal importance assigned to both components of the PHI ranking in terms of their weights is an arbitrary assumption rather than an empirically-derived one. For this reason, the results of a sensitivity analysis conducted with regard to various weight combinations (such as 70:30 or 30:70 for the NIRF and RSI parameters, respectively) show that the direction of Jadavpur University's reordering is robust, although its exact rank changes.

Table X. Proxy Happiness Index (PHI) by Institution

NIRF Rank	Institution	NIRF Score	RSI Score	Norm. NIRF	Norm. RSI	PHI
1	IIT Madras	90.14	31.7	100.0	47.8	73.9
2	IIT Delhi	88.12	30.3	93.0	45.7	69.4
3	IIT Bombay	85.08	20.9	82.5	31.5	57.0
4	IIT Kanpur	82.56	7.8	73.8	11.8	42.8

NIRF Rank	Institution	NIRF Score	RSI Score	Norm. NIRF	Norm. RSI	PHI
5	IIT Roorkee	79.31	22.8	62.6	34.4	48.5
6	IIT Kharagpur	78.05	8.2	58.2	12.4	35.3
7	IIT Guwahati	73.91	7.9	43.9	11.9	27.9
8	IIT Hyderabad	67.70	6.5	22.5	9.8	16.1
9	NIT Trichy	66.45	4.2	18.1	6.3	12.2
10	Jadavpur Univ.	61.20	66.3	0.0	100.0	50.0

Note: Normalized NIRF Score computed as $(\text{NIRF Score} - 61.20) / (90.14 - 61.20) \times 100$. Normalized RSI Score computed as $(\text{RSI Score} / 66.3) \times 100$. $\text{PHI} = 0.5 \times \text{Normalized NIRF} + 0.5 \times \text{Normalized RSI}$.

The governance case: Land as a finite resource

A. The Finite-Resource imperative

The difference between land and the other factors of production that an educational institution has access to is quite stark. Money can be raised and faculty members can be hired or educated, but land cannot be made at any particular place, and the provision of land to one educational institution will mean that the same land cannot be used for residential buildings, urban facilities, agricultural uses, or even commercial activities. With rapid urbanization, population density increasing, and constant disputes about acquiring land for public purposes, land grants to educational institutions need to be looked into more closely.

Existing institutional ranking frameworks do not measure the efficiency of land use. As per the NIRF's framework, 30% of the weight is dedicated to Teaching, Learning and Resources; 30% to Research and Professional Practice; 20% to Graduation Outcomes; 10% to Outreach and Inclusivity; and 10% to Perception (Ministry of Education, 2023). Land use efficiency does not feature among these weightages. This can be viewed more as a problem of governance than methodology: there being no metrics of land use and hence no rewards, institutions have no incentive to make efficient use of their land, while regulators have no data by which to identify inefficient land use or allocate land to new institutions based on needs.

B. International compact-campus benchmarks

International comparison reinforces the case that land quantity is not a reliable predictor of institutional standing (Table 5).

Table 5. International Compact-Campus Benchmarks vs. Indian Technical Institutions

Institution	Country	Campus (ac)	Students	QS World Rank (2024)	Programmes per 100 ac
MIT	USA	166	11,500+	1	~285
ETH Zürich (main campus)	Switzerland	~46	22,000	7	~350
Imperial College London	UK	~50	22,000	8	~300
Harvard (Cambridge core)	USA	~210	22,000	4	~190
IIT Kharagpur	India	2,100	22,000	271	~6.7
IIT Kanpur	India	1,055	10,000	285	~13.3
IIT Madras	India	617	14,000	227	~28
Jadavpur University	India	84	13,570	Not ranked	~179

Programme numbers are approximations according to total registered undergraduate, postgraduate and doctoral programs (QS Quacquarelli Symonds, 2024). The compact campus numbers for ETH Zürich and Imperial College London pertain to the footprint of their main urban campuses and not their total holdings.

The MIT, which ranks first in the 2024 QS World University Rankings, caters to approximately 11,500 students in a land area of 166 acres and has a programme density of around 285 programmes per 100 acres. The ETH Zürich, which ranks seventh in the world rankings, caters to over 22,000 students in

a land area of around 46 acres. The IIT Kharagpur caters to a similar number of students (22,000), spread across 2,100 acres, 45 times that of ETH Zürich – but with a programme density of around 6.7 programmes per 100 acres. This does not fit into the presumption that bigger land areas result in better institutions and, therefore, the premise behind the campus allocation policy in India must be questioned.

C. The future-expansion fallacy

Land acquisitions of large size often tend to be explained by the requirement for future expansion. This explanation is hard to test empirically because deferred expansion is likely to remain

deferred. The land acquired by the Indian Institute of Technology Kharagpur in 1951, covering 2,100 acres, still remains underdeveloped several decades after its acquisition. Once land is allocated to an institution, reallocating it would entail huge costs, akin to land banking.

Urban planning practice deals with a similar issue in commercial and residential development using the Floor Area Ratio (FAR) system, which makes the amount of building allowed contingent on the land size in acknowledgment of the limited nature of land and the public expense involved in inefficient use of land. Indian technical institutes are, in reality, exempt from similar intensity restrictions, making it possible to have a low density development even in situations where the

surrounding urban environment suffers from land shortage. If we use an approximate value of ₹1 crore per acre for peri-urban land and 3% opportunity cost yield in the case of IIT Kharagpur in comparison to a medium-sized campus, the annual recurring cost of this will run into many crores of rupees per year - an example of rough order of magnitude calculation rather than an audit of the value.

V. RECOMMENDATIONS

Table 6 summarises an integrated framework linking the evidence reviewed in this paper to recommended design standards and policy levers.

Table 6. Integrated Evidence-Based Campus Design Framework

Dimension	Recommended Standard	Evidence Source	Academic Outcome	Policy Lever	Priority
Outdoor green space	40–70 m ² per student	Galoyan & Poghosyan (2020)	GPA (+0.3 pts)	AICTE space-norm revision	High
Natural daylighting	DF ≥2% (labs); ≥3% (study areas)	Heschong Mahone Group (1999)	Test scores (+20–26%)	GRIHA/National Building Code integration	High
Acoustic quality	Ambient <35 dB; RT60 <0.6s	Shield & Dockrell (2008)	Reasoning (+15%)	NAAC classroom-acoustics audit	High
Thermal comfort	21–23 °C; passive-design priority	Seppänen & Fisk (2006)	Memory/speed (+14%)	AICTE infrastructure norms	High
Collaborative space	≥20% of floor area flexible	Jamieson et al. (2000)	Peer interaction (+21%)	NAAC peer-review criteria	Medium
Space productivity	RSI ≥20; utilisation 65–75%	HEFCE (2006); UGC (2022)	Resource efficiency	NIRF sub-score (5–10% weight)	High
Maker/fabrication space	Interdisciplinary location; open ≥18h/day	Doorley & Witthoft (2012)	Innovation output (+18%)	ATAL tinkering-lab integration	Medium
Universal accessibility	100% step-free; tactile paving	Story et al. (1998)	Retention (+7%)	RPwD Act compliance audit	Medium

Recommendation 1: Mandatory space productiveness audit. The All India Council for Technical Education (AICTE) and the University Grants Commission (UGC) should make it mandatory for all accredited technical institutes to report Space Productivity Audit each year, apart from their present NIRF reporting requirements. These include data on the space occupancy rates, RSI scores, and scheduling efficiency of their campuses.

Recommendation 2: Land allocation linked to RSI scores. Future land allocations should depend on the institution already utilizing space at least 65% of the time. Those with an underutilization gap greater than

20 percentage points should not be eligible for further land allotments unless they have presented a space activation strategy that is independently verified.

Recommendation 3: Phased construction for greenfield campuses. Construction of new IIT and NIT campuses needs to be done using a phased approach based on enrolment growth, thereby avoiding the problem of underprogramming at newer institutes such as IIT Hyderabad and IIT Guwahati. The interim master plan phases need to accommodate the presence of research parks, makerspaces, industry collaborations and community spaces that do not require core academic space.

Recommendation 4: Integration of LUEI in NIRF methodology. NIRF methodology needs to incorporate the calculation of LUEI, which would have its own weightage in the total composite ranking of 5 to 10 percent. As the campus size, enrolment, number of programmes and publications are already captured by NIRF data forms, there is no need for additional data collection.

Recommendation 5: Ecological adjustment factor. An Ecological Adjustment Factor needs to be factored into RSI and LUEI computations for institutions located within legally protected or ecologically sensitive natural zones, like the one established at IIT Madras, such that the institution is not penalized for protecting the use of land in order to serve its recognized ecological role.

Recommendation 6: Incentives for compact campus design. Institutions which have been able to achieve an RSI of 30 or more and a utilization factor of 70% or more need to be considered for recognition as Compact Campus Excellence from the Ministry of Education. Such recognition would be associated with grant priority in vertical construction, common infrastructure, and mixed-use development. The success of Jadavpur University in achieving a top ten NIRF performance with an 84-acre campus provides a documented precedent.

VI. DISCUSSION

A. The RSI paradox and its implications

The main finding from this study is that, in the current context, there is no relation between campus size and academic performance, in fact, sometimes even inversely proportional with spatially normalized performance. This cannot be seen as an indictment of larger campuses, since IIT Madras, with its 617 acres, has both high NIRF rankings and a high RSI (31.7). It shows that it is possible to reconcile campus size with spatial productivity when campus planning takes into account ecological, academic and social functions of space. The key difference made by the current analysis is not size itself, but the degree of intentionality behind it – shown in case studies like the 4-zoned campus master plan of IIT Delhi, heritage-integrated intensification of IIT Roorkee and the ecological

reserve of IIT Madras compared to campuses which had no equivalent design intensity despite having the same size, as in case of IIT Kharagpur and NIT Trichy in the current sample.

B. Campus design as a learning technology

However, the literature examined in previous section justifies treating the campus design as one part of the infrastructure of an institution as critical as the design of the curriculum, quality of the teaching faculty and digital infrastructure. The mechanisms described above, i.e., impact on attention, stress physiology, and self-regulated learning, have been established through repeated experimental and quasi-experimental studies conducted in many national contexts and therefore make a compelling case for designing country-specific guidelines for campus design in technical education institutions based on empirical evidence.

C. Digital transformation and the enduring value of physical space

The fast digitalisation of technical education through the course of the coronavirus pandemic reignited the discussion on the need for physical infrastructure of campus. From the available evidence, physical presence still holds certain unique advantages related to experiential, affective, and socio-emotional components of learning, which cannot be replicated online, such as practical work in labs, interactions with peers, and identity of institutions connected to specific locations. Research carried out at eighteen Indian technical institutions (Sharma & Nair, 2023) demonstrated that students who studied in fully digital courses in the 2020–21 academic year faced an average 12% deficit in terms of skill development and 19% deficit in peer-related learning. This indicates the continued importance of physical learning environment, despite the increasing ability to offer classes digitally, supporting the general thesis of the paper.

VII. CONCLUSION

On the basis of theoretical justification, comparative institutional analysis, two spatial-productivity measures, and an evidence-based design paradigm, this research claims that the design and productive utilization of space for technical education – not just

the size of this space – are materially linked to academic excellence. This link seems to function via at least three different mechanisms: environmental psychology mechanisms involving attention, stress, and motivation; socio-architecture mechanisms that facilitate or inhibit peer learning and interdisciplinary interaction; and symbolic mechanisms that affect institutional identity and aspiration through campus design. The comparative analysis of NIRF-ranked institutions suggests that comparable academic excellence has been obtained by a variety of institutions, varying in terms of their campus size and design ideology, ranging from the urban campus of Jadavpur University (84 acres) to the campus-town of IIT Kharagpur (2,100 acres). However, the RSI and utilization analyses demonstrate that there remains a strong gap between campus size and spatial productivity: six out of ten sampled institutions register estimated underutilization exceeding 20 percentage points, compared to a sample average utilization rate of 58%, given the benchmark of 75%.

The analysis above reveals that the more appropriate measure for policy-making in this case is not land area, but quality of design and productivity per unit of land area. There ought to be an incentive for institutions to create an ecological campus, which would have sound-proof architecture and thermal stability, as well as social interactions taking place in the specified utilization range of 65% to 75% in order to enhance Happiness Index Quality. The behavior of institutions is very sensitive to their rankings; therefore, the inclusion of land-productivity indicators in frameworks such as NIRF may prove to be more successful than land- allocation policy reform alone. International comparators such as MIT's research output at 166-acres and Jadavpur University's top ten national ranking at 84 acres reveal that density of knowledge is the better basis on which to make judgments about the capacities of the institutions in question. As India aims to realize its vision of a competitive knowledge economy in 2047, there needs to be land allocation and accreditation policy reform in India whereby land becomes the scarce resource that it is and the utilization of which needs periodic justification.

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