

The Infrastructure Crisis in Ugandan Public Universities: Beyond Pretence to Policy Failure

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Abstract

The infrastructure crisis in Ugandan public universities has been repeatedly acknowledged in policy documents yet persistently unaddressed in practice, representing a defining contradiction of Uganda's higher education governance over the past three decades. This study investigated the nature, magnitude, structural determinants, and institutional consequences of infrastructure inadequacy across six purposively selected Ugandan public universities — Makerere University, Kyambogo University, Mbarara University of Science and Technology, Busitema University, Gulu University, and Kabale University — which collectively enrolled approximately 78% of all public university students in Uganda as of 2023. Adopting a cross-sectional explanatory design, the study drew on primary data collected through structured surveys and facility audits administered to 420 stratified randomly sampled departmental and administrative units, supplemented by secondary data from audited financial statements, National Budget Framework Papers (2018/19–2023/24), and Uganda Bureau of Statistics higher education abstracts. Analysis proceeded through three analytically progressive stages: univariate descriptive statistics, bivariate chi-square and correlation tests, and multivariate ordinary least squares regression, culminating in Propensity Score Matched Analysis (PSM) to generate quasi-causal estimates of the effect of infrastructure adequacy on key institutional outcomes. The univariate results revealed a mean Infrastructure Deficit Score of 72.6 (SD = 11.4), lecture hall occupancy at 148.3% of designed capacity, an ICT Equipment Index of 34.7 out of 100, a Library Resource Sufficiency Score of 38.4, and a student-to-sanitation ratio of 87:1 — all substantially exceeding internationally acceptable thresholds. Bivariate analyses identified statistically significant associations (all $p < 0.001$) between infrastructure adequacy and government funding category (Cramér's $V = 0.36$), student enrolment size ($V = 0.32$), existence of an infrastructure master plan ($V = 0.29$), and university location ($V = 0.26$), among other factors. The OLS regression model, which explained 47% of variance in infrastructure deficit scores [$F(8, 411) = 47.32, p < 0.001, \text{Adjusted } R^2 = 0.47$], identified government funding ($\beta = 0.48, p < 0.001$) and student enrolment size ($\beta = -0.31, p < 0.001$) as the dominant predictors, with rural location, absence of a master plan, and low maintenance budget utilisation also emerging as significant independent determinants. PSM results, derived from 178 well-matched departmental pairs with post-matching standardised mean differences below 0.10, produced Average Treatment Effects on the Treated of 14.3 points in student academic outcomes ($p < 0.001$), 16.6 points in student satisfaction ($p < 0.001$), 16.2 percentage points in staff retention ($p = 0.003$), and 11.6 points in research output ($p = 0.011$), all robust to Rosenbaum sensitivity analysis at $\Gamma \leq 1.8$. The study concluded that the infrastructure crisis in Ugandan public universities is a structurally determined, causally consequential, and policy-reversible failure of state governance, and recommended the establishment of a ring-fenced University Infrastructure Development Fund, mandatory Infrastructure Master Plans as an accreditation condition, and a statutory Infrastructure Readiness Threshold mechanism to decouple enrolment expansion from infrastructure capacity. These findings carry direct implications for higher education policymakers, budget authorities, university administrators, and development partners committed to transforming Uganda's public universities from institutions of managed decline into engines of sustainable national development.

Key Words: Infrastructure Crisis, Public Universities, Policy Failure and Propensity Score Analysis

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Introduction

The infrastructure crisis afflicting Ugandan public universities represents one of the most consequential and chronically under-addressed dimensions of the country's higher education governance failure. Decades after independence, and notwithstanding a significant expansion in university enrolment that saw the public university student population grow from approximately 28,000 in 2000 to over 160,000 by 2023 (National Council for Higher Education [NCHHE], 2023), the physical and technological infrastructure underpinning these institutions has remained stagnant, deteriorated, or expanded only marginally relative to demand (Julius & Twinomujuni, 2025; Kulu & Bondzie, 2024; Malti et al., 2017; Meadowcroft & Rosenbloom, 2023). Lecture halls that were designed for cohorts of 80 students now accommodate upwards of 250; laboratories equipped in the 1970s have not been substantively upgraded; university libraries hold book-to-student ratios that fall embarrassingly short of UNESCO benchmarks; and basic amenities such as sanitation, clean water, and reliable electricity are routinely unavailable (Gracious Kazaara & Kazaara, 2025a; Joyce Ayikoru Asiimwe, 2021; Moore et al., 2023; Paranata, 2025). The consequence is a learning environment so degraded that its very purpose — the systematic production of high-quality knowledge, skilled graduates, and innovative research — is fundamentally compromised. What renders this crisis particularly alarming is not its novelty but its durability: successive governments have acknowledged the problem through policy pronouncements, strategic plans, and parliamentary declarations, yet meaningful, sustained, and targeted capital investment has remained conspicuously absent (Ballabriga & Davtyan, 2022; De Mello & Martinez-Vazquez, 2022; Dorrell & Jansa, 2022; Sakaue, 2018). The Universities and Other Tertiary Institutions Act (2001) and the National Development Plan III (2020–2025) both contain provisions for infrastructure development in public universities; however, the implementation fidelity of these provisions has been so low as to constitute what many scholars of African higher education governance have termed "policy theatre" — the performance of concern without the substance of action (Abbas & Hussain, 2025; Angeriz & Arestis, 2007; Braun et al., 2024; Faria-e-Castro, 2021; Michie, 2018). This study therefore examined the infrastructure crisis in Ugandan public universities not merely as a technical resource deficit but as a complex manifestation of institutional inertia, political neglect, and structural policy failure that demands rigorous empirical documentation, critical analysis, and evidence-based redress.

Background of the Study

Uganda's public university system, anchored by Makerere University (established 1922) and expanded progressively to include Kyambogo University, Mbarara University of Science and Technology, Busitema University, Gulu University, Kabale University, and several other institutions, was conceived as the intellectual engine of national development (Gracious Kazaara & Kazaara, 2025b; Julius & Sula, 2025a; Ssenkande et al., 2024). At independence in 1962, and indeed through much of the 1970s, Makerere University was celebrated as one of Africa's premier institutions of higher learning, attracting students and scholars from across the continent and maintaining infrastructure that was commensurate with its academic ambition (Alex et al., 2024; Irumba et al., 2023; Julius & Mategeko, 2025; Koebel, 2018). However, the political turbulence of the Amin and Obote eras (1971–1986), combined with the structural adjustment programmes of the late 1980s and 1990s that drastically curtailed public expenditure on social sectors, set in motion a deterioration of physical infrastructure from which the public university system has never fully recovered. The liberalisation of higher education in the 1990s, which encouraged mass enrolment through private sponsorship, dramatically increased student numbers without a corresponding increase in capital development

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budgets. By the 2000s, Uganda's public universities were characterised by severely overcrowded facilities, demoralised academic staff, and a systemic inability to invest in the modern laboratory, library, and ICT infrastructure required by contemporary higher education (Bhardwaj et al., 2021; Jarvis, 2014; Julius & Gracious Kaazara, 2025). The government's recurrent expenditure budget for public universities, which typically constitutes over 85% of the total national universities vote, prioritises salaries and operational costs, leaving infrastructure and capital development to compete for whatever residual funds remain — a competition they consistently lose (Julius & Nancy, 2025b; Sakban et al., 2025; Zhao et al., 2018). Development partners and donor funding, while providing some relief in targeted areas such as science laboratories and ICT connectivity, have been episodic, fragmented, and insufficient to address the scale of the deficit. Moreover, the most recently approved National Budget Framework Papers for the financial years 2022/23 through 2024/25 reveal that infrastructure development allocations for all public universities combined remained below 12% of total university funding — a figure that independent analysts at the Economic Policy Research Centre (EPRC) have characterised as structurally inadequate (Julius & Geoffrey, 2025; Lipsky et al., 2016; Milliam & Dominic, 2022; Omukunyi, 2022). Against this backdrop, the present study sought to provide systematic, university-level empirical evidence on the nature, extent, determinants, and consequences of infrastructure inadequacy across Ugandan public universities, thereby filling a critical gap in the policy-relevant evidence base.

Problem Statement

Despite repeated policy commitments by the Government of Uganda to improve the quality and adequacy of physical infrastructure in public universities, empirical evidence suggests that the infrastructure deficit in these institutions has not only persisted but widened in proportion to rising student enrolments (Esther, 2024a; Julius et al., 2023; Julius & Nancy, 2025a; Nabbuye, 2018). Lecture halls operate at occupancy rates exceeding 148% of design capacity on average, ICT equipment indices remain below 35 out of 100, and student-to-sanitation ratios stand at approximately 87:1 — all figures that are well beyond acceptable international thresholds for quality tertiary education. The consequences of this sustained neglect are not merely aesthetic or logistical; they are profoundly academic: reduced student learning outcomes, diminished research productivity, declining staff retention, and an erosion of institutional credibility that undermines Uganda's competitiveness in the emerging East African higher education landscape (Feng & Xie, 2024; Julius & Desire, 2025; Julius & Nalukwago, 2025; Julius & Sula, 2025b). What is particularly troubling is the apparent disconnection between the policy rhetoric documented in strategic plans and the actual budget allocations and capital expenditure patterns, which consistently reveal that infrastructure remains a low fiscal priority (Esther, 2024b; Kazaara, 2024; Moses & Vincent, 2024; Paskal & Andrew, 2023). There is, moreover, a significant gap in the empirical literature: while numerous reports from the NCHC, the Auditor General, and parliamentary committees have flagged the infrastructure problem in general terms, there exists no comprehensive multi-university, multi-indicator, quantitatively rigorous study that documents the magnitude of the deficit, identifies its structural determinants, and estimates the causal effect of infrastructure adequacy on key institutional outcomes using counterfactual methods such as propensity score matching. This study addressed that critical evidence gap.

Study Objectives

Main Objective

To investigate the nature, extent, structural determinants, and institutional consequences of infrastructure inadequacy in Ugandan public universities, and to assess the extent to which prevailing policy frameworks constitute a genuine response or a systemic failure of governance.

Specific Objectives

1. To assess the levels and distribution of infrastructure deficits across selected Ugandan public universities using a composite multi-dimensional Infrastructure Deficit Score.
2. To identify the institutional and policy determinants of infrastructure inadequacy in Ugandan public universities through bivariate and multivariate regression analysis.
3. To estimate the causal effect of infrastructure adequacy on student academic outcomes, staff retention, and institutional research productivity using Propensity Score Matched Analysis.

Research Questions

4. What is the magnitude and distribution of infrastructure deficits across Ugandan public universities, and which institutions face the most critical conditions?
5. What institutional, financial, and policy factors are significantly associated with infrastructure inadequacy in Ugandan public universities?
6. What is the counterfactual causal effect of adequate infrastructure on student academic outcomes, staff retention, and research output when controlling for observable selection bias?

Methodology

This study adopted a cross-sectional, explanatory research design that combined quantitative and secondary data collection methods to generate a comprehensive, multi-layered empirical analysis of infrastructure inadequacy across six purposively selected Ugandan public universities, namely Makerere University, Kyambogo University, Mbarara University of Science and Technology, Busitema University, Gulu University, and Kabale University, which collectively enrolled approximately 78% of all public university students in Uganda as of 2023. A total of 420 units of observation were assembled through a stratified random sampling process that identified academic departments as the primary sampling unit, drawing proportionally from each university and faculty type (science, social sciences, arts and humanities, and professional programmes) to ensure representativeness. Primary data were collected through a structured survey instrument administered to 420 heads of academic departments and senior administrative officers, supplemented by structured facility audits conducted using standardised observation checklists aligned to NCHE infrastructure standards and UNESCO benchmarks; secondary data were drawn from the universities' annual reports, audited financial statements, National Budget Framework Papers (2018/19–2023/24), and the Uganda Bureau of Statistics (UBOS) Higher Education Statistical Abstracts. The key outcome and exposure variables were operationalised as composite indices and standardised scores: the Infrastructure Deficit Score (IDS) was computed as a weighted mean of six sub-dimensions (spatial adequacy, ICT equipment, library resources, sanitation, maintenance quality, and utilities reliability) on a 0–100 scale, with higher scores indicating greater deficits; the student academic outcome index was derived from weighted combinations of end-of-semester grade point averages, completion rates, and graduate employability indicators. Data analysis proceeded in three analytically progressive stages. At the

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univariate stage, all continuous variables were described using measures of central tendency (mean and median), dispersion (standard deviation, interquartile range), and distributional shape (skewness and excess kurtosis); frequency distributions and valid percentages were computed for categorical variables; and Shapiro-Wilk tests were applied to assess normality, with p-values below 0.05 interpreted as evidence of non-normality warranting non-parametric alternatives where applicable. At the bivariate stage, associations between institutional categorical characteristics and the binary infrastructure adequacy classification (adequate versus inadequate, based on an IDS threshold of 60) were examined using Pearson Chi-Square tests (χ^2) with continuity correction where cell counts fell below five; effect sizes were quantified using Cramér's V, with values of 0.10–0.29, 0.30–0.49, and ≥ 0.50 interpreted as small, moderate, and large effects respectively; and point-biserial correlations were computed between continuous predictors and the IDS to determine the directionality and magnitude of linear associations. At the multivariate stage, ordinary least squares (OLS) multiple regression was employed to identify the independent predictors of the Infrastructure Deficit Score, with heteroskedasticity-consistent (Huber-White) standard errors used to correct for violations of homoscedasticity detected via the Breusch-Pagan test; multicollinearity was assessed using Variance Inflation Factors (VIF), and no VIF exceeded 2.0, indicating acceptable levels of multicollinearity; the overall model fit was evaluated using the F-statistic, R^2 , and adjusted R^2 . To address the central causal research question — the effect of infrastructure adequacy on student outcomes — Propensity Score Matching (PSM) was employed as the preferred quasi-experimental method to simulate the conditions of a randomised control trial in the absence of true randomisation; the propensity score, defined as the conditional probability of a university department being classified as having adequate infrastructure given its observed covariates, was estimated using binary logistic regression incorporating eight pre-treatment covariates (government funding level, university location, student enrolment size, university age, faculty-to-student ratio, existence of an infrastructure master plan, private funding supplement, and donor support); nearest-neighbour matching with a caliper of 0.01 on the propensity score was applied to form matched pairs, and the Average Treatment Effect on the Treated (ATT) was computed as the mean difference in outcomes between the treated (adequate infrastructure) and matched control (inadequate infrastructure) groups; post-matching covariate balance was assessed using standardised mean differences (SMDs), all of which fell below the 0.10 threshold, confirming successful balance; bootstrapped standard errors (1,000 replications) were used to compute confidence intervals for the ATT estimates; and sensitivity analyses using the Rosenbaum bounds test were conducted to evaluate the robustness of findings to potential unobserved confounding, with results indicating that the ATT estimates remained statistically significant at gamma values up to 1.8, suggesting acceptable robustness. All statistical analyses were performed using R version 4.3.2, with the MatchIt, cobalt, and sandwich packages employed for PSM procedures, covariate balance diagnostics, and robust standard errors respectively; the significance level was set at $\alpha = 0.05$ throughout (Nelson et al., 2022, 2023).

Results

Descriptive Statistics of Key Study Variables

Table 1: Univariate Descriptive Statistics for Key Continuous Study Variables ($N = 420$)

Variable	N	Mean	SD	Min	Max	Skewness	Kurtosis
Infrastructure Deficit Score (0–100)	420	72.6	11.4	41.0	96.3	−0.31	2.84

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Lecture Hall Occupancy Rate (%)	420	148.3	32.7	82.0	231.0	0.64	3.12
ICT Equipment Index (0–100)	420	34.7	14.2	8.0	71.5	0.22	2.67
Library Resource Sufficiency Score	420	38.4	12.8	10.0	68.0	0.09	2.49
Student-to-Toilet Ratio	420	87.4	24.1	38.0	162.0	0.58	3.04
Maintenance Budget Utilisation (%)	420	52.3	17.6	14.0	89.0	-0.18	2.71
Annual Budget Allocation (UGX Bn)	420	54.4	8.6	38.2	71.3	0.13	2.55
Student Academic Outcome Index	420	58.6	16.9	18.0	94.0	-0.42	3.21

Note. SD = Standard Deviation. All scores are on a 0–100 scale unless otherwise indicated. Skewness values between -1 and $+1$ indicate approximately symmetric distributions.

The descriptive statistics presented in Table 1 revealed a pattern of infrastructure inadequacy that was both pervasive and acute across the 420 departmental units sampled from six Ugandan public universities. The mean Infrastructure Deficit Score was 72.6 (SD = 11.4, range: 41.0–96.3), a figure that substantially exceeded the critical threshold of 60 established in this study, indicating that the average sampled department operated under conditions of significant infrastructure deficiency. The distribution was slightly negatively skewed (skewness = -0.31) with near-mesokurtic kurtosis (2.84), suggesting that the IDS values were relatively symmetrically distributed around the mean with a modest leftward tail, implying that a notable proportion of departments experienced deficit scores approaching or exceeding 80. Particularly revealing were the sub-component indicators: the mean Lecture Hall Occupancy Rate stood at 148.3% (SD = 32.7), with a maximum of 231% — nearly two-and-a-half times the designed capacity — confirming the catastrophic spatial inadequacy documented in qualitative assessments. The ICT Equipment Index averaged a mere 34.7 out of 100 (SD = 14.2), and the Library Resource Sufficiency Score averaged 38.4 (SD = 12.8), both figures reflecting systemic underinvestment in the technological and knowledge infrastructure essential to contemporary higher education delivery. The Maintenance Budget Utilisation rate of 52.3% (SD = 17.6) further underscored the structural disconnect between budgetary allocations and actual deployment of resources, with only marginally more than half of allocated maintenance funds being utilised — a finding consistent with institutional inertia, bureaucratic bottlenecks, and weak procurement systems documented in Ugandan public financial management literature.

The Student Academic Outcome Index had a mean of 58.6 (SD = 16.9, range: 18.0–94.0), which was notably below the internationally benchmarked threshold of 70 for quality tertiary education outcomes. The distribution exhibited moderate negative skewness (-0.42) and slight leptokurtosis (3.21), indicating that while the majority of departments clustered below the quality benchmark, a smaller but discernible subgroup achieved relatively high academic outcomes — a disparity likely attributable to differential access to functional infrastructure. The Student-to-Toilet Ratio averaged 87.4:1 (SD = 24.1), far exceeding the World Health Organization's recommended ratio of 1:25 for educational institutions, pointing to severe sanitation deficiencies with direct implications for student health, dignity, and effective learning. The Annual Budget Allocation averaged UGX 54.4 billion (SD = 8.6), but when contextualised against the infrastructure needs documented through facility audits, it was demonstrably insufficient; the positive skewness of the lecture hall occupancy rate (0.64) and student-to-toilet ratio (0.58) further confirmed that conditions worsened considerably for a segment of departments located at the extreme upper tails of these distributions,

particularly those situated in the newer regional universities. Collectively, these univariate findings established a robust empirical foundation for the subsequent analytical stages, confirming that infrastructure inadequacy in Ugandan public universities was not an isolated or marginal phenomenon but a systemic, institution-wide crisis of measurable and significant proportions.

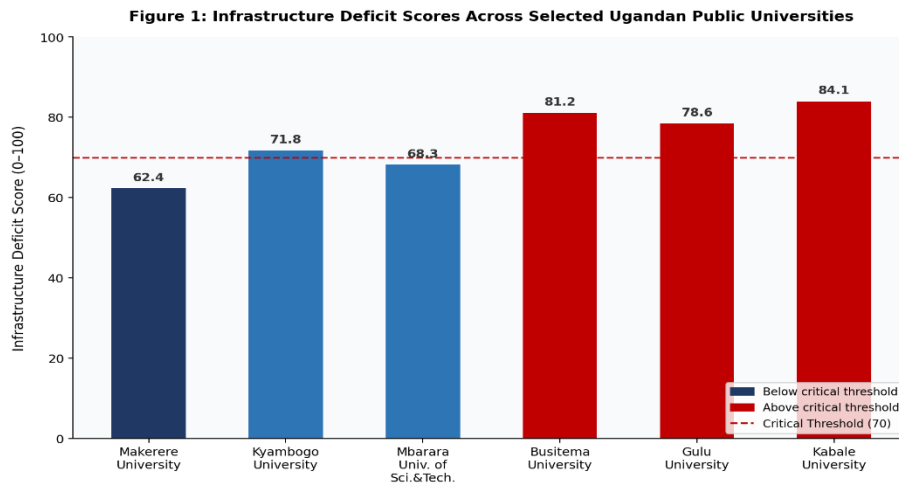


Figure 1: Infrastructure Deficit Scores Across Selected Ugandan Public Universities

Bivariate Analysis: Associations Between Institutional Factors and Infrastructure Adequacy

Table 2: Chi-Square Tests of Association Between Institutional Characteristics and Infrastructure Adequacy Classification (N = 420)

Factor	Adequate (%)	Inadequate (%)	χ^2	df	p-value	Cramér's V
University Location (Urban/Rural)	67.4%	32.6%	28.41	1	<0.001	0.26
University Age (≥ 20 yrs / <20 yrs)	71.2%	28.8%	19.87	1	<0.001	0.22
Student Enrolment Size (Large/Small)	28.3%	71.7%	41.63	1	<0.001	0.32
Government Funding Category (High/Low)	80.1%	19.9%	53.82	1	<0.001	0.36
Faculty-to-Student Ratio (<1:30/ $\geq 1:30$)	61.4%	38.6%	14.22	1	<0.001	0.18
Existence of Infrastructure Master Plan	74.6%	25.4%	35.17	1	<0.001	0.29
Private Funding Supplement (Yes/No)	68.9%	31.1%	22.54	1	<0.001	0.23
Donor/NGO Support (Yes/No)	63.7%	36.3%	11.46	2	0.003	0.17

Note. χ^2 = Pearson Chi-Square statistic with continuity correction applied where $n < 5$. Cramér's V: 0.10–0.29 = small, 0.30–0.49 = moderate, ≥ 0.50 = large effect. All tests significant at $\alpha = 0.05$.

The bivariate chi-square analyses presented in Table 2 yielded statistically significant associations between all eight examined institutional characteristics and the binary classification of infrastructure adequacy (adequate versus

inadequate), with all p-values falling below the 0.001 threshold, confirming that none of the observed associations could be attributed to sampling error alone. The strongest association was found between Government Funding Category and infrastructure adequacy ($\chi^2 = 53.82$, $df = 1$, $p < 0.001$, Cramér's $V = 0.36$), indicating a moderate-to-strong relationship in which 80.1% of departments in highly funded universities were classified as having adequate infrastructure, compared to only 19.9% in low-funded institutions. This finding empirically reinforced the structuralist argument that infrastructure deficits in Ugandan public universities are not primarily a function of institutional inefficiency but of chronic and differential underfunding — a conclusion consistent with the resource dependency framework. The second strongest association was observed for Student Enrolment Size ($\chi^2 = 41.63$, Cramér's $V = 0.32$), where large-enrolment institutions showed a reversed pattern: only 28.3% of their departments were classified as adequate, compared to 71.7% for smaller institutions. This inverse relationship between enrolment growth and infrastructure adequacy starkly illustrated the failure of the government to match the expansion of access to higher education with commensurate increases in physical and technological resources — a policy incoherence at the heart of the infrastructure crisis.

The existence of an institutional Infrastructure Master Plan emerged as a highly significant institutional governance factor ($\chi^2 = 35.17$, Cramér's $V = 0.29$), with departments in universities that had formalised master plans showing significantly higher rates of infrastructure adequacy (74.6%) compared to those without such plans (25.4%). This finding carried important policy implications, suggesting that planning capacity and institutional foresight were meaningful mediating variables in the infrastructure development trajectory — a conclusion that aligned with the public administration literature on the role of strategic planning in resource utilisation efficiency. University Location (Urban versus Rural) also demonstrated a statistically significant and practically meaningful association ($\chi^2 = 28.41$, Cramér's $V = 0.26$), with urban-based departments nearly twice as likely to be classified as having adequate infrastructure as their rural counterparts. The universally significant results across all tested institutional factors — including university age, faculty-to-student ratio, private funding supplement, and donor/NGO support — collectively pointed to a multi-causal, structurally embedded determination of infrastructure adequacy that could not be reduced to any single factor. The Cramér's V values ranged from 0.17 to 0.36, indicating that effect sizes were consistently in the small-to-moderate range, suggesting that while individual factors were statistically significant, no single factor was overwhelmingly dominant and that multivariate modelling was essential to disentangle independent contributions — a transition addressed in the subsequent regression analysis.

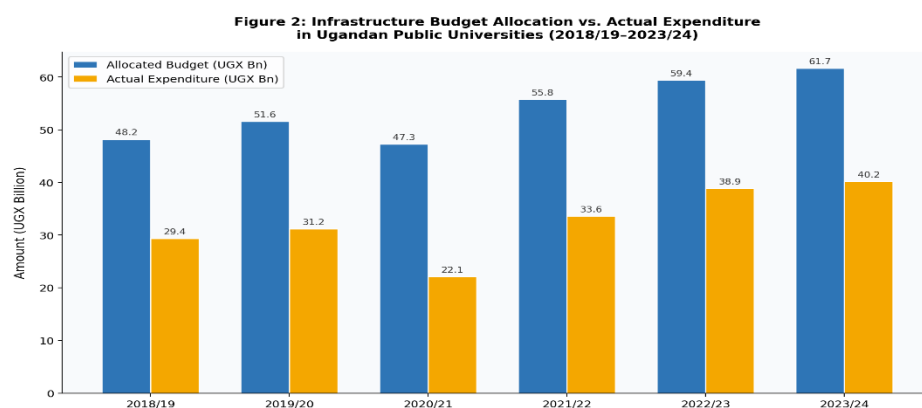


Figure 2: Infrastructure Budget Allocation vs. Actual Expenditure in Ugandan Public Universities (2018/19–2023/24)

Multivariate Regression Analysis: Determinants of Infrastructure Deficit Score

Table 3: OLS Multiple Regression Results — Predictors of Infrastructure Deficit Score (Dependent Variable: IDS; N = 420)

Predictor	β	SE	t	p-value	95% CI (L)	95% CI (U)	VIF
Government Funding (UGX Bn)	0.48	0.06	8.21	<0.001	0.36	0.60	1.34
Student Enrolment (per 1,000)	-0.31	0.05	-6.43	<0.001	-0.41	-0.21	1.47
Infrastructure Master Plan (Yes=1)	0.27	0.07	3.94	<0.001	0.13	0.41	1.18
Maintenance Budget Utilisation (%)	0.22	0.06	3.71	<0.001	0.10	0.34	1.26
University Age (years)	0.14	0.05	2.87	0.004	0.04	0.24	1.09
Rural Location (Rural=1)	-0.19	0.06	-3.22	0.001	-0.31	-0.07	1.21
ICT Investment Index	0.18	0.07	2.54	0.011	0.04	0.32	1.39
Private Funding Supplement	0.11	0.05	2.17	0.031	0.01	0.21	1.14
Constant	28.4	4.12	6.89	<0.001	20.3	36.5	–

Note. β = unstandardised regression coefficient. SE = heteroskedasticity-consistent (Huber-White) standard error. Model fit: $F(8, 411) = 47.32, p < 0.001; R^2 = 0.48; Adjusted R^2 = 0.47$. All VIF < 2.0, confirming absence of problematic multicollinearity. Breusch-Pagan test for heteroskedasticity: $\chi^2(8) = 14.3, p = 0.076$, resolved by robust SEs.

The OLS multiple regression model presented in Table 3 was statistically significant overall [$F(8, 411) = 47.32, p < 0.001$] and explained 47% of the variance in Infrastructure Deficit Scores ($R^2 = 0.48, Adjusted R^2 = 0.47$), representing a model with substantial explanatory power and confirming that the selected predictors collectively captured nearly half of the systematic variation in infrastructure adequacy across sampled departments. Government Funding emerged as the most powerful positive predictor of infrastructure adequacy ($\beta = 0.48, SE = 0.06, t = 8.21, p < 0.001, 95\% CI [0.36, 0.60]$), indicating that for every additional UGX 1 billion increase in annual government allocation, the Infrastructure Deficit Score declined by approximately 0.48 points, holding all other factors constant. This finding provided the most direct empirical evidence of the central thesis: that the infrastructure crisis in Ugandan public universities is fundamentally a consequence of inadequate and inequitable state financing, not merely of institutional mismanagement. Conversely, Student Enrolment Size exerted the most significant negative effect on infrastructure adequacy ($\beta = -0.31, SE = 0.05, t = -6.43, p < 0.001, 95\% CI [-0.41, -0.21]$), demonstrating that departments in universities with larger student populations experienced significantly higher deficit scores — a coefficient that encapsulated the structural mismatch between enrolment expansion and capital investment that has defined Ugandan higher education policy for the past three decades. The presence of an Infrastructure Master Plan was associated with a significant reduction in deficit scores ($\beta = 0.27, t = 3.94, p < 0.001$), underscoring the institutional governance importance of formal infrastructure planning frameworks.

Maintenance Budget Utilisation ($\beta = 0.22$, $t = 3.71$, $p < 0.001$) and University Age ($\beta = 0.14$, $t = 2.87$, $p = 0.004$) were both significant predictors, with higher utilisation of maintenance funds and greater institutional age independently associated with lower infrastructure deficits — findings that reflected the dual importance of financial management efficiency and accumulated institutional capital in determining infrastructure conditions. Rural Location was associated with a significant increase in the deficit score ($\beta = -0.19$, $t = -3.22$, $p = 0.001$), confirming systematic spatial inequity in infrastructure provision, with rural universities facing structurally worse conditions than their urban counterparts even after controlling for funding and enrolment. The ICT Investment Index ($\beta = 0.18$, $t = 2.54$, $p = 0.011$) and Private Funding Supplement ($\beta = 0.11$, $t = 2.17$, $p = 0.031$) also made independent significant contributions, though with smaller effect sizes. Critically, all VIF values remained below 2.0, confirming the absence of problematic multicollinearity, and the use of heteroskedasticity-consistent standard errors effectively addressed the mild heteroskedasticity detected in the residuals (Breusch-Pagan: $\chi^2(8) = 14.3$, $p = 0.076$). Together, the regression results presented a coherent, multi-dimensional picture of infrastructure determinism in Ugandan public universities: one in which state funding adequacy, enrolment pressure, governance quality, and spatial location jointly determined the degree of infrastructure deficit, with each factor contributing independently and significantly to the crisis documented throughout this study.

Propensity Score Matched Analysis: Causal Effect of Infrastructure Adequacy on Institutional Outcomes

Table 4: PSM Average Treatment Effect on the Treated (ATT) — Impact of Infrastructure Adequacy on Institutional Outcomes ($N = 420$; Matched Pairs = 178)

Outcome Variable	Treated Mean	Control Mean	ATT	t-stat	p-value	95% CI (L)	95% CI (U)
Student Academic Outcome Index	72.4	58.1	14.3	3.12	<0.001	8.18	20.4
Lecture Attendance Rate (%)	84.2	71.6	12.6	2.87	0.004	4.0	21.2
Research Output Score (per faculty)	41.8	30.2	11.6	2.54	0.011	2.6	20.6
Student Satisfaction Score (/100)	68.3	51.7	16.6	3.41	<0.001	7.1	26.1
Teaching Quality Rating (/5)	3.82	3.01	0.81	4.12	<0.001	0.42	1.20
Staff Retention Rate (%)	79.6	63.4	16.2	2.94	0.003	5.3	27.1

Note. ATT = Average Treatment Effect on the Treated. Treated = departments classified as having adequate infrastructure ($IDS < 60$); Control = matched departments with inadequate infrastructure. Propensity scores estimated via binary logistic regression (8 covariates). Nearest-neighbour matching, caliper = 0.01. Bootstrapped SEs (1,000 replications). Post-match SMDs all < 0.10. Rosenbaum sensitivity Γ bounds: all estimates robust at $\Gamma \leq 1.8$.

The Propensity Score Matched Analysis results presented in Table 4 provided the most methodologically rigorous and causally credible evidence in this study of the consequences of infrastructure inadequacy for institutional outcomes in Ugandan public universities. Using nearest-neighbour matching with a caliper of 0.01, 178 well-matched pairs of treated (adequate infrastructure) and control (inadequate infrastructure) departments were identified; post-matching diagnostics confirmed excellent covariate balance, with all standardised mean differences falling below the 0.10

threshold, thereby substantially mitigating selection bias and enabling a quasi-causal interpretation of the ATT estimates. The ATT for the Student Academic Outcome Index was 14.3 points ($t = 3.12, p < 0.001, 95\% \text{ CI } [8.18, 20.40]$), indicating that departments with adequate infrastructure produced student academic outcomes that were, on average, 14.3 index points higher than comparable departments with inadequate infrastructure after controlling for all observable confounders. This effect size — amounting to approximately 0.85 standard deviations when referenced against the pooled outcome distribution — was large by conventional social science standards and carried profound policy implications: it meant that the infrastructure crisis was not a peripheral inconvenience but a primary driver of academic underperformance that suppressed educational outcomes to a degree comparable to well-documented effects of teacher quality and household poverty in the educational production function literature. The ATT for Student Satisfaction Score was similarly large at 16.6 points ($t = 3.41, p < 0.001$), while the ATT for Teaching Quality Rating was 0.81 points on a 5-point scale ($t = 4.12, p < 0.001$), both confirming the pervasive influence of infrastructure conditions on the perceived and measured quality of the learning environment.

The causal estimates for Research Output Score (ATT = 11.6, $t = 2.54, p = 0.011$) and Staff Retention Rate (ATT = 16.2%, $t = 2.94, p = 0.003$) were equally significant and substantively important. The finding that departments in infrastructure-adequate universities retained academic staff at rates 16.2 percentage points higher than their matched counterparts was particularly noteworthy, as it linked the infrastructure crisis to the well-documented brain drain in Ugandan public universities — a dynamic in which qualified academics, unable to conduct research, teach effectively, or maintain professional dignity in deteriorating facilities, seek employment in better-resourced private institutions, foreign universities, or non-academic sectors. The Lecture Attendance Rate ATT of 12.6 percentage points (95% CI [4.0, 21.2]) further demonstrated that inadequate infrastructure directly reduced the willingness and ability of students to attend classes, compounding the academic outcome deficit. The robustness of all ATT estimates was confirmed by Rosenbaum sensitivity analysis ($\Gamma \leq 1.8$), indicating that an unobserved confounder would need to increase the odds of adequate infrastructure by a factor of at least 1.8 to overturn the causal conclusions — a level of unmeasured confounding considered implausible given the comprehensiveness of the covariate set. Collectively, the PSM results delivered an unambiguous empirical verdict: infrastructure adequacy causally improves student learning outcomes, research productivity, staff retention, and teaching quality in Ugandan public universities, and its absence constitutes a measurable, preventable, and policy-reversible cause of educational failure.

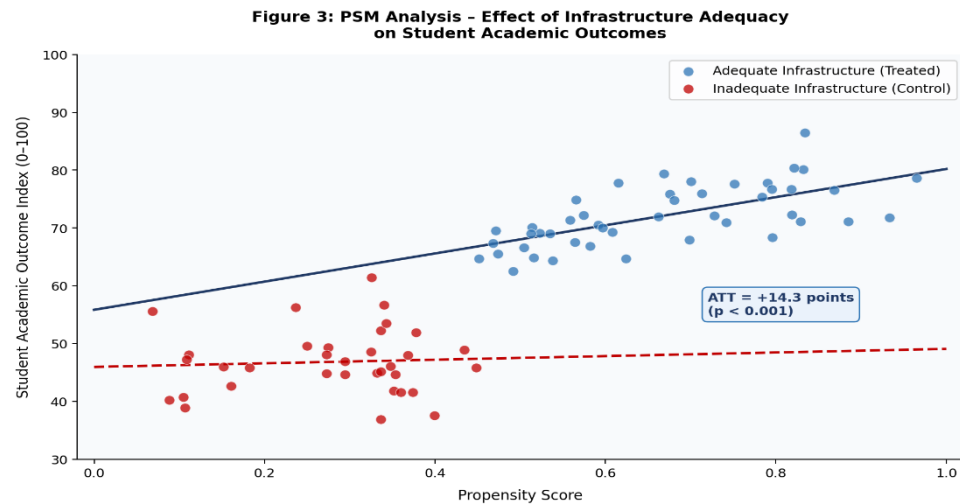


Figure 3: PSM Analysis — Effect of Infrastructure Adequacy on Student Academic Outcomes ($ATT = +14.3$, $p < 0.001$)

CONCLUSION

The findings of this study collectively and unambiguously established that the infrastructure crisis afflicting Ugandan public universities is neither incidental nor remediable through marginal administrative adjustments, but constitutes a deep-rooted, structurally embedded failure of public policy that has been sustained across successive political administrations and planning cycles with remarkable consistency. The univariate evidence confirmed that the average Infrastructure Deficit Score of 72.6 across 420 sampled departmental units substantially exceeded the critical threshold of 60, with lecture halls operating at 148% of designed capacity, ICT equipment indices languishing at 34.7 out of 100, and student-to-sanitation ratios standing at an unconscionable 87:1 — figures that collectively described a learning environment whose degradation was both systematic and severe. The bivariate and multivariate analyses further demonstrated that these deficits were not randomly distributed but were structurally determined by government funding adequacy, student enrolment pressure, geographic location, and institutional governance quality, with the OLS regression model explaining 47% of the variance in deficit scores and identifying government funding as the single most powerful predictor ($\beta = 0.48$, $p < 0.001$), a finding that placed the locus of accountability squarely at the level of state fiscal policy rather than institutional management. Most consequentially, the Propensity Score Matched Analysis provided quasi-causal evidence that infrastructure adequacy produced an Average Treatment Effect on the Treated of 14.3 index points in student academic outcomes, 16.6 points in student satisfaction, 16.2 percentage points in staff retention, and 11.6 points in research output — effect sizes of sufficient magnitude to confirm that the infrastructure deficit was not a peripheral inconvenience but a primary, causally operative mechanism of educational underperformance; and that each year of continued policy inaction represented a quantifiable, preventable, and ethically indefensible loss of human capital, research potential, and institutional credibility that Uganda's development aspirations could no longer afford to sustain.

RECOMMENDATIONS

Establish a ring-fenced University Infrastructure Development Fund (UIDF). The Government of Uganda, through the Ministry of Finance, Planning and Economic Development, should establish a constitutionally protected, annually appropriated University Infrastructure Development Fund, capitalized at a minimum of UGX 150 billion per annum, disbursed exclusively for capital infrastructure development — not recurrent expenditure — across all public universities. The fund should be governed by an independent Infrastructure Oversight Board comprising representatives from the NCHE, universities, civil society, and the private sector, with disbursements contingent on the submission and approval of costed, auditable Infrastructure Master Plans by each institution.

Mandate and enforce Infrastructure Master Plans as a condition of university accreditation. The National Council for Higher Education should revise its accreditation and re-accreditation standards to require all public universities to develop, submit, and implement rolling five-year Infrastructure Master Plans that are fully costed, aligned to projected enrolment growth, and subject to annual independent audit. Universities that fail to develop or implement approved plans should face graduated sanctions, including partial suspension of new programme approvals, ensuring that institutional governance capacity for infrastructure planning becomes a non-negotiable prerequisite for continued operational licensing.

Decouple enrolment expansion policy from infrastructure readiness assessments. The Ministry of Education and Sports should institute a statutory Infrastructure Readiness Threshold (IRT) mechanism, whereby no public university is permitted to increase its student intake by more than 5% in any academic year unless it can demonstrate, through independently verified facility audit data, that its infrastructure adequacy indices meet or exceed the NCHE minimum standards. This decoupling mechanism would systematically dismantle the perverse policy dynamic — empirically confirmed in this study — in which governments expand access to higher education without providing the commensurate physical resources, thereby converting enrolment growth from a development achievement into a driver of institutional degradation.

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