Bima Journal of Science and Technology, Vol. 9(2A) Jun, 2025 ISSN: 2536-6041

DOI: 10.64290/bimagombe.v9i2A.1065

A Model to Predict the Perception of University Stakeholders Towards a Smart Campus

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ABSTRACT

This study developed a model to predict the perception of university stakeholders toward a smart campus, emphasizing a human-centered, learning-oriented model. The identified stakeholders include students, academic staff, the management team, non-academic staff, vendors (technology providers and system integrators) and regulatory bodies. The research employed the Analytical Hierarchical Processing (AHP) to evaluate stakeholders' roles based on four criteria: influence on campus, dependency of the campus on the stakeholder, engagement of the stakeholder, and impact of the stakeholder on campus. Purposive sampling was used to select individuals who have significant knowledge about a smart campus, ensuring participants have relevant insights into the stakeholder dynamics. Result from the pairwise comparison indicates, students were identified as the most influential stakeholders, followed by academic staff and the management team. Similarly, students, academic staff, and the management team ranked highest in their impact on the campus. In terms of dependency, students and academic staff shared the highest criteria weight (0.27), with the management team following with a criteria weight of 0.26. While in terms of smart campus engagement, academic staff ranked the highest (0.42), followed by students (0.21) and the management team (0.09). Non-academic staff, vendors, and regulatory bodies consistently ranked lower across all criteria. The results were verified using a consistency ratio (CR ≤ 0.1), indicating reliability and suitability for decision-making processes.

Keywords: Smart Campus; University Stakeholders; Analytical Hierarchical Processing; Pairwise Comparison.

INTRODUCTION

The concept of a smart campus represents a significant evolution in the management and enhancement of educational environments, characterized by the integration of advanced technologies to create more efficient, responsive, and connected spaces (Polin et al.,2023).

Dong et al. (2020), described a smart campus as an educational setting with extensive interactions with other interdisciplinary areas in the context of a smart city, permeated with enabling technology for smart services to improve educational performance while meeting stakeholders' needs.

The way educational institutions work has changed as a result of the integration of cutting-edge technologies and data-driven solutions, fostering creativity, efficiency, and better learning experiences (Haleem, et al., 2022). The quest of excellence in higher education has become inextricably intertwined with the implementation of smart campus solutions as universities and colleges work to develop more connected, intelligent, and responsive settings (Sneesl, et al., 2022).

As educational institutions strive to embrace this transformative shift, it becomes evident that the successful implementation of a smart campus extends beyond the mere adoption of technological solutions. Most importantly, it requires the active and informed

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participation of a diverse range of stakeholders, including students, parents, management, administrative staff, academic and non-academic staff, regulatory bodies, vendors, and consultants (Dong, et al., 2020).

This study aims to explore how a comprehensive approach that incorporates the perspectives and needs of these varied stakeholders can lead to a more effective and efficient smart campus. Each stakeholder group plays a distinct and important role in shaping the campus environment.

Students are the primary users of campus facilities and services, and their experiences and feedback are essential for ensuring that technological solutions meet their needs and enhance their campus life. Parents often have a vested interest in the safety, efficiency, and overall quality of the campus environment as it impacts their children's education and well-being (Mustafa et al.,2021). Management and administrative staff are responsible for the strategic planning and operational oversight of smart campus initiatives, requiring them to balance technological innovations with institutional goals (Zhang et al.,2021).

Academic and non-academic staff utilize campus resources and technologies in their day-to-day activities, necessitating their involvement in the design and implementation phases to ensure that these solutions support their work effectively. Regulatory bodies set the standards and compliance requirements that must be adhered to, influencing the scope and execution of smart campus technologies. Vendors and consultants bring specialized expertise and technological solutions, playing a crucial role in the deployment and integration of smart technologies.

By addressing the needs and contributions of each of these stakeholders, this research developed a comprehensive model that integrates advanced technologies while fostering meaningful stakeholder engagement. The goal is to enhance campus efficiency and user satisfaction by creating a smart campus that is both technologically advanced and responsive to the diverse needs of its community.

MATERIALS AND METHODS

The study utilized purposive sampling to select relevant participants and apply the AHP to validate and analyze the data collected through survey. The AHP is a decision-making model used to solve complex problems by breaking them down into simpler components, it involves the following steps: (1) objective: define the problem and decision-making process (2) Structure the hierarchy: decompose the problem into a hierarchical structure criterion, and (3) Pairwise comparison: compare elements at each level with decision alternatives (Saaty, 1980; Sneerl, 2022).

The AHP creates a hierarchical model of these three levels. Each level is guided by the objectives of evaluating the criteria, comparing the choice alternatives for each criterion, and ranking these alternatives. Accordingly, to rank the criteria or factors, the AHP employs expert pair-wise comparisons, judgments concerning the factors are represented by "how one element dominates another in relation to a certain attribute", calculate weights and synthesize results (Sneerl, 2022). **S**takeholder identification and the AHP process is illustrated in Figure 1.

Bima Journal of Science and Technology, Vol. 9(2A) Jun, 2025 ISSN: 2536-6041

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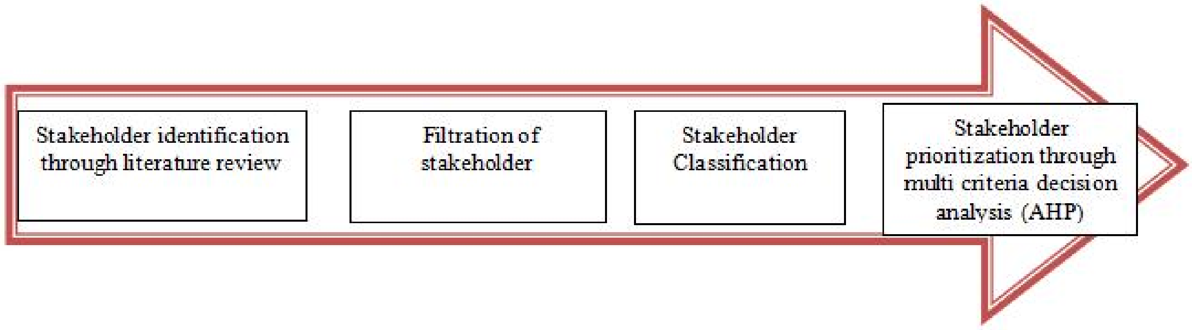

Figure 1: Stakeholder identification and AHP process Adapted from (Sneerl, 2022).

Research Process

Stakeholder Identification

At this stage, stakeholders are identified and categorized. Stakeholders relevant to the smart campus model include students, management team, Academic staff, Non-Academic staff, Vendors and Technology Providers, System integrators, and Regulatory bodies.

Survey

Sampling Approach: purposive sampling was used to select individuals who have a significant role or influence on the smart campus. This approach ensures that participants have relevant insights into the stakeholder dynamics.

Selection Criteria: participants were chosen based on their understanding, position, and experience in smart campus initiatives. For example: Key decision-makers (e.g., members of the management team), Active users or beneficiaries (e.g., students and academic staff), Providers and integrators involved in smart campus technologies.

Survey Design and Validation

Survey Question were developed to create a survey instrument with questions designed to assess the importance of each stakeholder based on key criteria such as:

- Influence on Campus Operations
- Impact on Smart Campus Experience
- Dependency of the Campus on the Stakeholder
- Engagement in Campus Process

AHP Validation: AHP will be used to validate the survey questions by comparing and ranking the importance of each criterion to the other. This involves:

- Structuring the hierarchy with the goal, criteria, and stakeholders.
- Conducting pairwise comparisons of the criteria and stakeholders for each criterion.
- Calculating priority weights for each criterion and stakeholder to ensure the questions reflect their relative importance accurately.

Data Collection

Survey questions were administered to the purposively sampled stakeholders to obtain reliable responses. Data/responses collected will be compiled for analysis.

Data Analysis Using AHP

1. ***Pairwise Comparisons***: Pairwise comparisons of stakeholders with respect to each criterion will be performed. The AHP scale will be used to rate the importance of stakeholders relative to each criterion.

2. ***Compute Weights***: AHP will be used to calculate the relative weights of each stakeholder based on the pairwise comparisons. This involves:

- Deriving weights for each criterion and stakeholder.

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- Aggregating the results to obtain overall importance scores for each stakeholder.

RESULTS

The enhancement of the model was done by the addition of relevant stakeholders such as Vendors (technology providers and system integrators) and Regulatory bodies into the service layer of the HLSC smart campus model. The enhanced model is shown in Figure 2

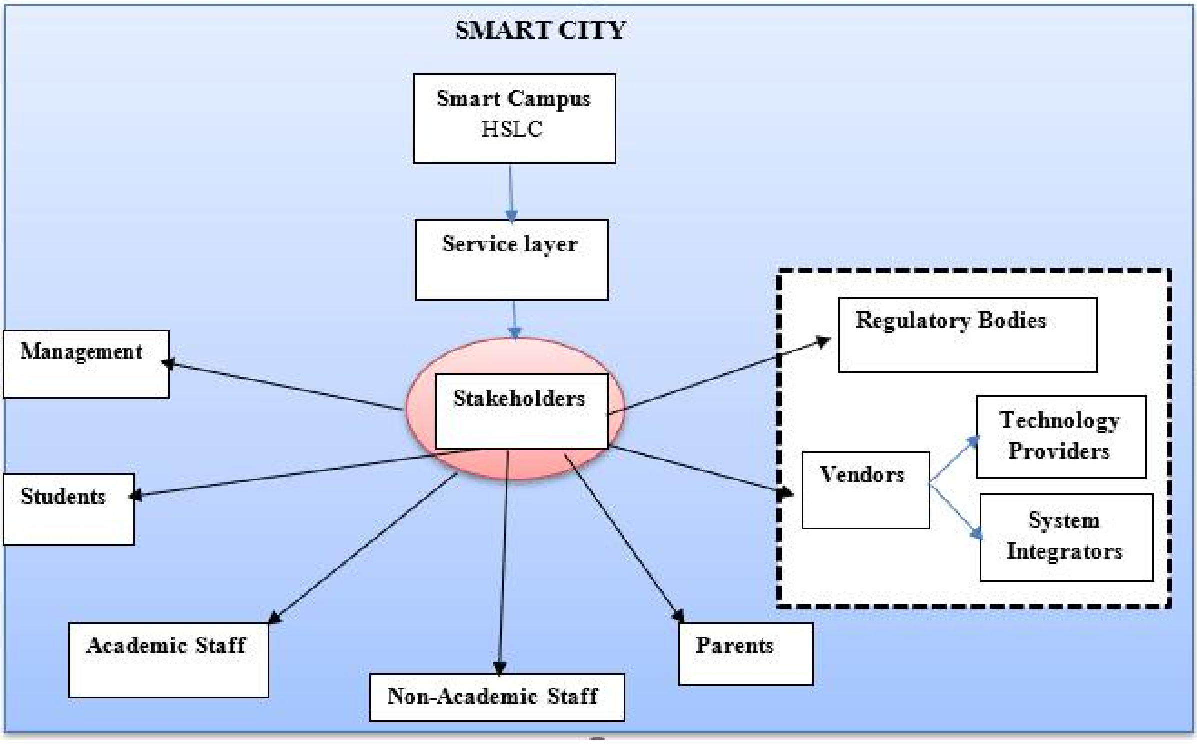

Figure 2: Enhanced HSLC Model

Data Collection and Predevelopment Phase

This section presents the data collection method and analysis used by decision makers to rank the most important smart campus stakeholders base on four (4) different criteria such as the stakeholders influence on smart campus activities, impact of the stakeholder on smart campus, Dependency of the campus on the stakeholder and engagement of the stakeholder in smart campus activities.

The phase includes a survey, which was developed by adopting an AHP also known as MCDM (Sneel et al.,2022) problems. According to Sneel et al. (2022), the AHP divides a MCDM problem into three levels namely: Goal, Criteria and decision alternatives. With each level, guided by the goal/objective of evaluating the criteria and comparing the choice alternative for each criterion or factor. The AHP use expert pair wise comparison, mainly as one element dominates or is more important over another. Figure 3 illustrates the Smart campus factors identification and AHP process.

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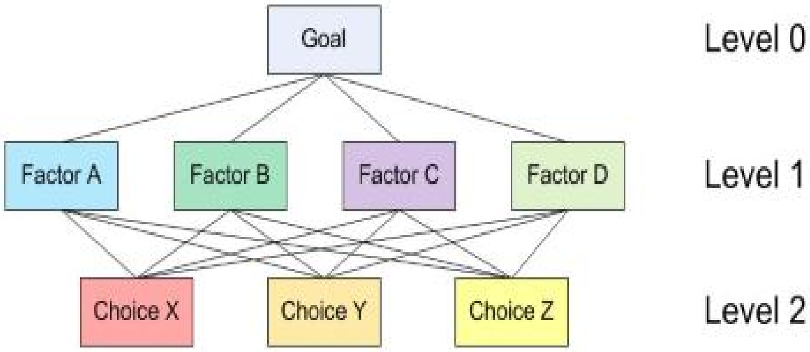

Figure 3: Smart campus factors identification and AHP process (Tecknomo, 2022).

This phase entails developing an acceptable AHP model hierarchy comprised of the aim, criteria or factors, sub-criteria or sub-factors, and alternatives. As this study is focused on evaluating the relevant stakeholders such as Students, Academic staff, Non-Academic staff, Management Staff, Vendors (Technology Providers and System Integrators), and Regulatory bodies. The AHP hierarchy consist of Goal, Criteria, and evaluation technique by the decision makers. This aim (objective) is positioned at the top of the hierarchical architecture (level 0). Level 0 includes the main criteria or factors, while Level 1 includes the factors that will be use to evaluate expert decisions on relevant smart campus stakeholders. Figure 4.3 shows the hierarchical model for the current study. The most significant stakeholder/factors obtained through the AHP analysis are ranked according to the factors' normalized weights.

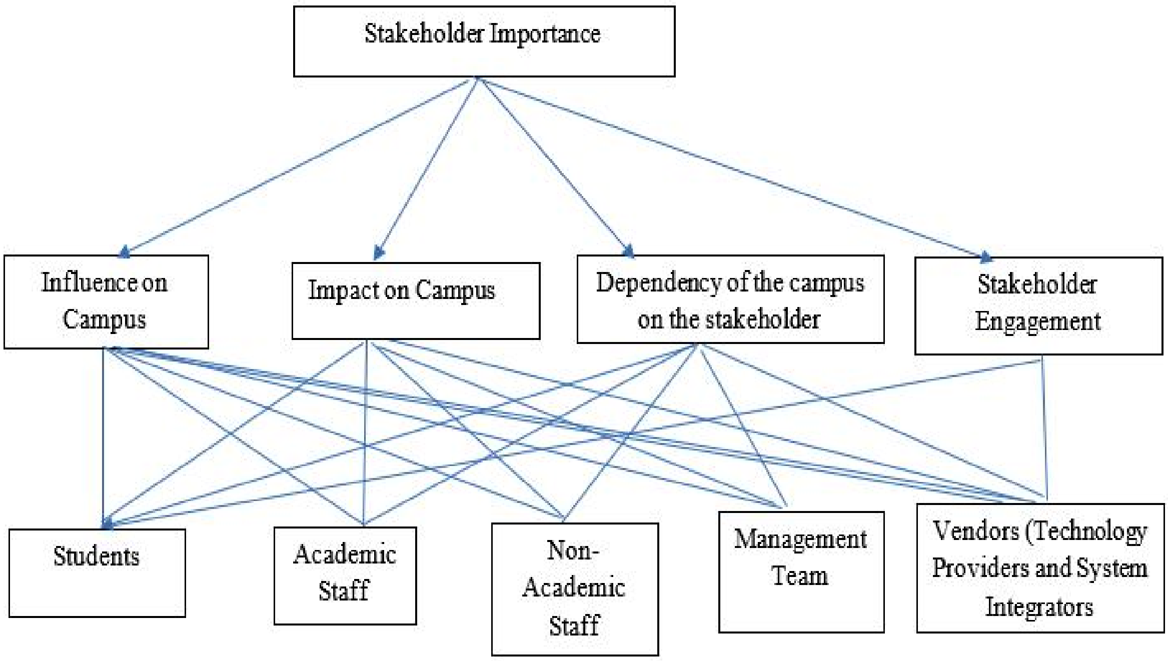

Figure 4: AHP Process for the study

Case study

The study adopted purposive sampling by targeting Postgraduate students, academic and non-academic staff of Computer Science Department, and ICT staff of Kaduna State University. These set of people were chosen because they are actively involved in research of the latest technologies and have

DOI: 10.64290/bimagombe.v9i2A.1065

sound knowledge of how a traditional campus can be transformed into a smart campus.

The study identified the most important criteria or factor (smart campus University stakeholder) based on the view of a diverse group of end users to transform traditional campus into a smart campus by the prioritization of relevant stakeholders, those actively involved in smart campus activities whom this technology will be deployed for, who will be the end users. Table 1 shows the AHP relative important scale by Saaty (1980).

Table 1: Relative Important Scale of AHP

Intensity of Importance	Definition
1	Equally important
3	Moderately Important
5	Strongly Important
7	Very Strongly Important
9	Extremely Strongly Important
2,4,6,8	Intermediate values (Reaching compromise values between 1, 3,5,7,9)

A questionnaire containing the main criteria as well as their corresponding factors was prepared based on a pair-wise comparison matrix using Saaty's nine-point scale. Accordingly, description of all of the categories and criteria were communicated to the respondents while the questionnaires were being administered.

The study administered twenty (20) questionnaires based on the study by Sneel (2022), where seventeen (17) responses was received, out of which twelve (12) responses were recorded and analyzed as valid data that met the consistency requirement of the study. Table 4.2 shows the descriptive statistics.

Computation of Normalized Weight Factors

This section discussed about how each criterion was normalized. Microsoft Excel version 2020 (MS EXCEL) was utilized to analyze the data obtained from the respondents.

Table 2: Participant's Profile

Demographic Profile	Categories	Type of degree	Total
Position	Students	M.Sc.	6
		PGD	1
	ICT Staff	M.Sc.	2
	Academic and non-academic staff	PHD	3

Constructing Aggregate Comparison Matrices of the Factors

Using the geometric mean technique, the aggregated evaluation for each item of the comparison matrix is obtained by summing the responses collected from the respondents on the pair-wise comparisons of factor/stakeholder categories, value obtained from respondents' judgement are presented as integers (Sneel 2022). Given by the formula in equation 1.

$$A_{ij} = \left(\prod_{i=1}^{n} .\right)^{1/n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

In developing the Pair-Wise Comparison Matrices of the Factors, the Pair-wise comparisons is done to determine which stakeholder is more important/relevant base on key criteria such influence on campus, impact, dependency of the campus on the stakeholder and stakeholder engagement (Saaty, 1980).

For example, If the i^{th} element is greater than the j^{th} element, the integer is placed in the i^{th} row and j^{th} column of the comparison matrix,

DOI: 10.64290/bimagombe.v9i2A.1065

and therefore its corresponding reciprocal is entered in the i^th^ row and j^th^ column of the matrix respectively, also, if the criteria or factors being compared are equal, a value of one (1) is written.

A comparison matrix $A = A_{IJ}$ Where A_{IJ} is a comparison matric of order n where n is the number of criteria compared given in equation 2.

$$A_{IJ} = \frac{1}{A_{IJ}}, i, j = 1,2,3,4 \ldots n \ldots\ldots\ldots\ldots (2)$$

Stakeholder Evaluation Based on Influence on Campus Operation

Table 3 shows the stakeholder evaluation of the relative importance of the most influential stakeholders in a smart campus.

Table 3: Stakeholder Evaluation of the most relevant stakeholder, based on Influence on Campus operation.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies
Student	1	4	5	5	6	6
Academic Staff	$\frac{1}{4}$	1	3	3	4	5
Non-Academic Staff	$\frac{1}{5}$	$\frac{1}{3}$	1	$\frac{1}{2}$	3	3
Management Team	$\frac{1}{5}$	$\frac{1}{3}$	2	1	3	4
Vendors	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{3}$	1	2
Regulatory Bodies	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	1
Total	1.97	6.05	11.55	10.1	17.5	21

Factor Normalization to Determine Priority Vector/Criteria Weight

For each category (main factor) and sub-factor, a normalized matrix N is generated to calculate the priority. The normalized matrix N is constructed based on the corresponding comparison matrix A. The value in each column of the pair wise comparison matrix is summed as shown in equation 3.

$$X_{ij} = \sum_{i=1}^{n} A_{ij} \ldots\ldots\ldots\ldots (3)$$

Next, each element in the matrix is divided by its column total to generate a normalized pair wise matrix given in equation 4, and results, shown in Table 4.

$N = [n_i]$

Where,

$$n_{iy} = \frac{A_{ij}}{\sum_{i=1}^{n} A_{ij}} \ldots\ldots\ldots\ldots (4)$$

The normalized weight values for the stakeholder evaluation of the relative importance of the most influential stakeholders in a smart campus, is shown in Table 4.

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Table 4: Normalized Weight Values.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies
Student	0.50	0.66	0.43	0.49	0.34	0.28
Academic Staff	0.12	0.16	0.26	0.29	0.22	0.23
Non-Academic Staff	0.10	0.04	0.08	0.04	0.17	0.14
Management Team	0.10	0.04	0.17	0.09	0.17	0.19
Vendors	0.08	0.04	0.03	0.02	0.05	0.09
Regulatory Bodies	0.08	0.03	0.02	0.02	0.02	0.04
Total	0.98	0.97	0.99	0.95	0.97	0.97

The value total is approximately 1, indicating it has been normalized.

The priority (weights) for each factor is then derived by taking the average of the elements of each row N.

$$\omega_i = \frac{\sum_{i=1}^{n} n_{ij}}{n} \quad \ldots(5)$$

the priority vector W, if $W = [\omega x]$ is a column matrix of order n_{ij} given in equation 5. and results presented in Table 4.5. where n = 6

Table 5: Priority/Criteria Weights.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weights
Student	0.50	0.66	0.43	0.49	0.34	0.28	0.45
Academic Staff	0.12	0.16	0.26	0.29	0.22	0.23	0.21
Non-Academic Staff	0.10	0.04	0.08	0.04	0.17	0.14	0.09
Management Team	0.10	0.04	0.17	0.09	0.17	0.19	0.12
Vendors	0.08	0.04	0.03	0.02	0.05	0.09	0.05
Regulatory Bodies	0.08	0.03	0.02	0.02	0.02	0.04	0.04
Total	0.98	0.97	0.99	0.95	0.97	0.97	0.96 ≅ 1

The priority /criteria weight sums up to one (1), as shown in Table 5, this implies each criterion importance or contribution to the overall decision-making process has been normalized, indicating that all criteria are equally weighted in terms of significance (Sneerl, 2022).

From Table 5, the criteria weights indicate students are the most influential smart campus university stakeholder, with a criteria weight of 0.45 followed by Academic (0.21) and Management staff (0.12).

Validating the Result of all Comparison Matrices through Consistency Tests

The result of the comparison matrices is validated through consistency testing. This is because people are frequently inconsistent in their responses to questions. Hence, it is important to evaluate the levels of consistency in the comparison matrices. This aids researchers in validating the predicted priority vectors (Sneerl, 2022).

To achieve this, the study utilized the CR as the measurement index in pair-wise comparisons. If $CR \leq 0.10$ The amount of inconsistency in matrix A is acceptable and hence, the ranking result is acceptable (Gupta, 2017). A matrix "A" is said to be consistent if the Eigen Value (λ_{max}) is closer to n, formula for consistency ratio is given in equation 6.

$$CR = \frac{CI}{RI} \quad \ldots\ldots\ldots(6)$$

Where CI is the consistency index given by

$$CI = \frac{\lambda_{Max} - n}{n - 1} \quad \ldots\ldots\ldots(7)$$

The Eigen Vector λ_{Max} is gotten by taking the average of the consistency measure CR and **n** sample size (or number of criteria) compared in the matrix.

A CI, as shown in equation 7, is used to measure the degree of inconsistency in the square matrix ***A***. Saaty (1980), compared the estimated CI with the same index derived from a randomly generated square matrix, called the RCI as shown in Table 6. The value of RCI for *n* less than three is zero and they are not shown in the Table 4.6.

Table 6: Random Index Table (RI)

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RCI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Source: Adapted from Saaty; Sneerl, (2022).

The largest eigenvalue (λ_{max}) is calculated using the formula

$$\boldsymbol{\lambda_{max}} = \frac{\frac{\sum (Aw_i)}{w_i}}{n} \quad \ldots\ldots\ldots 8$$

Where: A is the pairwise comparison matrix, w is the normalized priority vector (eigen vector), Aw is the matrix-vector product and n is the number of criteria.

λ_{max} is calculated as the average of this values also known as the consistency measure/ratio (CR)

The CR for the most influential stakeholder in a smart campus is shown in Table 7

Table 7: Consistency Measure

Stake-holder	**Student**	**Academic Staff**	**Non-Academic Staff**	**Management Team**	**Vendors**	**Regulatory Bodies**	**Criteria Weights**	**Consistency Measure (CR)**
Student	0.50	0.66	0.43	0.49	0.34	0.28	0.45	6.4
Academic Staff	0.12	0.16	0.26	0.29	0.22	0.23	0.21	6.47
Non-Academic Staff	0.10	0.04	0.08	0.04	0.17	0.14	0.09	6.0
Management Team	0.10	0.04	0.17	0.09	0.17	0.19	0.12	6.35
Vendors	0.08	0.04	0.03	0.02	0.05	0.09	0.05	6.36
Regulatory Bodies	0.08	0.03	0.02	0.02	0.02	0.04	0.04	6.13
Total	0.98	0.97	0.99	0.95	0.97	0.97	$0.96 \cong 1$	$\boldsymbol{\lambda_{Max} = 6.28}$

DOI: 10.64290/bimagombe.v9i2A.1065

From equation 6

$$CI = \frac{\lambda_{Max} - n}{n-1}$$

$$CI = \frac{6.28 - 6}{6-1}$$

$$CI = 0.056$$

$CR = \frac{CI}{RI}$, $n = 6$ corresponds to 1.24 from Saaty's Random index (RI) Table

$$CR = \frac{0.056}{1.24}$$

$$CR = 0.04 < 0.10.$$

The consistency ratio of $CI = 0.04 < 0.10$ suggests the decision makers judgement are generally consistent and reliable for decision making.

Impact on Smart Campus Operation

Table 8 shows the stakeholder evaluation of the most relevant stakeholder, based on Impact on smart Campus operations.

Table 8: Stakeholder Evaluation of the most relevant stakeholder, based on Impact on smart Campus operations.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies
Student	1	3	4	5	3	4
Academic Staff	$\frac{1}{3}$	1	4	5	3	4
Non-Academic Staff	$\frac{1}{4}$	$\frac{1}{4}$	1	$\frac{1}{5}$	3	3
Management Team	$\frac{1}{5}$	$\frac{1}{5}$	5	1	5	5
Vendors	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{5}$	1	2
Regulatory Bodies	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{2}$	1
Total	2.3	5.0	14.6	11.6	15.5	19

The normalized weight values of the most relevant stakeholder, based on Impact on smart Campus operations is shown in Table 9.

DOI: 10.64290/bimagombe.v9i2A.1065

Table 9: Normalized Weight Values.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weights
Student	0.43	0.60	0.27	0.43	0.18	0.19	0.35
Academic Staff	0.13	0.20	0.27	0.45	0.18	0.19	0.23
Non-Academic Staff	0.10	0.05	0.06	0.01	0.18	0.19	0.09
Management Team	0.08	0.04	0.02	0.07	0.36	0.32	0.14
Vendors	0.08	0.06	0.02	0.08	0.06	0.06	0.06
Regulatory Bodies	0.10	0.05	0.02	0.08	0.03	0.03	0.05
Total	0.92	1.00	0.66	0.98	0.99	0.98	0.92

Result indicates Students, academic staff and management team are the most relevant stakeholder, based on Impact on smart Campus operations.

Table 10 shows the Consistency measure of the most relevant stakeholder, based on Impact on smart Campus operations.

Table 10: Consistency Measure.

Stake-holders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weights	Consistency Measure
Student	0.44	0.60	0.25	0.44	0.18	0.2	0.35	8.42
Academic Staff	0.13	0.20	0.25	0.44	0.18	0.2	0.23	6.21
Non-Academic Staff	0.11	0.02	0.06	0.01	0.18	0.5	0.09	6.11
Management Team	0.07	0.03	0.38	0.07	0.36	0.3	0.20	6.4
Vendors	0.13	0.06	0.01	0.01	0.06	0.1	0.06	6.0
Regulatory Bodies	0.11	0.05	0.01	0.01	0.03	0.05	0.04	6.25
Total							0.97≡ 1	$\boldsymbol{\lambda_{Max} = 6.56}$

$$\lambda_{Max} = \frac{8.42 + 6.21 + 6.11 + 6.4 + 6.0 + 6.25}{6}$$

$$\lambda_{Max} = 6.56$$

From equation 6,

$CR = \frac{CI}{RI}$, *n =6* corresponds to 1.24 from Saaty's Random index (RI) Table

$$CR = \frac{0.112}{1.24}$$

$$CR = 0.09 < 0.10.$$

The consistency ratio of $CI = 0.09 < 0.10$ suggests the decision makers judgement are generally consistent and reliable for decision making.

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Dependency of the Campus on the Stakeholder

Table 11 shows Stakeholder Evaluation of Dependency of the Campus on the Stakeholder

Table 11: Stakeholder Evaluation of Dependency of the Campus on the Stakeholder.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies
Student	1	5	5	$\frac{1}{4}$	5	5
Academic Staff	$\frac{1}{5}$	1	5	5	6	5
Non-Academic Staff	$\frac{1}{5}$	$\frac{1}{5}$	1	$\frac{1}{5}$	4	5
Management Team	4	$\frac{1}{5}$	5	1	5	5
Vendors	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{5}$	1	4
Regulatory Bodies	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{4}$	1
Total	5.8	6.76	16.45	6.85	21.25	25

The normalized weight factors of the Stakeholder evaluation in terms of dependency of the Campus on the Stakeholder is shown in Table 12.

Table 12: Normalized Factors.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weights
Student	0.17	0.73	0.30	0.03	0.23	0.2	0.27
Academic Staff	0.03	0.14	0.30	0.72	0.28	0.2	0.27
Non-Academic Staff	0.03	0.02	0.06	0.02	0.18	0.2	0.08
Management Team	0.68	0.02	0.30	0.14	0.23	0.2	0.26
Vendors	0.02	0.02	0.01	0.02	0.04	0.16	0.04
Regulatory Bodies	0.03	0.02	0.01	0.02	0.01	0.04	0.02
Total							$0.94 \equiv 1$

Result indicates smart campus depends equally on Students and Academic staff with a criteria weight of 0.27. followed by management staff and non-academic staff, with a criteria weight of 0.26 and 0.08 respectively.

The criteria measure for stakeholder dependency on smart campus is shown in Table 13

Bima Journal of Science and Technology, Vol. 9(2A) Jun, 2025 ISSN: 2536-6041

DOI: 10.64290/bimagombe.v9i2A.1065

Table 13: Criteria Measure.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weights	Criteria Measure
Student	0.17	0.73	0.30	0.03	0.23	0.2	0.27	8.62
Academic Staff	0.03	0.14	0.30	0.72	0.28	0.2	0.27	8.7
Non-Academic Staff	0.03	0.02	0.06	0.02	0.18	0.2	0.08	6.2
Management Team	0.68	0.02	0.30	0.14	0.23	0.2	0.26	8.03
Vendors	0.02	0.02	0.01	0.02	0.04	0.16	0.04	6.75
Regulatory Bodies	0.03	0.02	0.01	0.02	0.01	0.04	0.02	9.5
Total							0.94 $\equiv 1$	$\boldsymbol{\lambda_{Max}} = \mathbf{7.9}$

$$CR = \frac{0.392}{1.24}$$
$$CR = 0.3 > 0.10.$$

The consistency ratio of $CI = 0.3 > 0.10$ suggests the decision makers judgement are inconsistent. With a $CR = 0.5$ exceeding the acceptable threshold of 0.1. this inconsistency suggests potential challenges in achieving reliable prioritization of the most important stakeholder with regards to the dependency of the stakeholder for a smart campus, caused due to subjective variability in the judgements provided by the respondents, which can be addressed through re-evaluation of the comparisons and engaging participants in a discussion to refine their judgements. Despite this limitation, the results provide valuable insights into stakeholder perceptions that can guide further investigation.

Stakeholder Engagement on Smart Campus

Evaluation of Stakeholder Engagement on Smart Campus is shown in Table 14.

Table 14: Evaluation of Stakeholder Engagement on Smart Campus.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies
Student	1	$\frac{1}{5}$	4	5	4	5
Academic Staff	5	1	5	5	6	6
Non-Academic Staff	$\frac{1}{4}$	$\frac{1}{5}$	1	$\frac{1}{4}$	$\frac{1}{5}$	5
Management Team	$\frac{1}{5}$	$\frac{1}{5}$	4	1	$\frac{1}{5}$	5
Vendors	$\frac{1}{4}$	$\frac{1}{6}$	5	5	1	5
Regulatory Bodies	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	1
Total	6.9	1.92	19.2	16.45	11.6	27

Normalized weight factors of the evaluation of Stakeholder, in terms of smart campus engagement is shown in Table 15.

DOI: 10.64290/bimagombe.v9i2A.1065

Table 15: Normalization of priority factors.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weight
Student	0.14	0.10	0.20	0.30	0.34	0.18	0.21
Academic Staff	0.72	0.52	0.26	0.30	0.51	0.22	0.42
Non-Academic Staff	0.03	0.10	0.05	0.01	0.01	0.18	0.06
Management Team	0.02	0.10	0.20	0.06	0.01	0.18	0.09
Vendors	0.03	0.08	0.26	0.30	0.08	0.18	0.1
Regulatory Bodies	0.02	0.08	0.01	0.01	0.01	0.03	0.02
Total							0.9 ≡ 1

Result indicates in terms of smart campus engagement, Academic staff ranked highest with a criteria weight of 0.42 followed by students.

Criteria weights for stakeholder evaluation in terms of smart campus engagement is shown in Table 16.

Table 16: Criteria Measure.

Stakeholders	Student	Academic Staff	Non-Academic Staff	Management Team	Vendors	Regulatory Bodies	Criteria Weight	Criteria Weight
Student	0.14	0.10	0.20	0.30	0.34	0.18	0.21	6.67
Academic Staff	0.72	0.52	0.26	0.30	0.51	0.22	0.42	6.90
Non-Academic Staff	0.03	0.10	0.05	0.01	0.01	0.18	0.06	6.0
Management Team	0.02	0.10	0.20	0.06	0.01	0.18	0.09	6.33
Vendors	0.03	0.08	0.26	0.30	0.08	0.18	0.1	6.1
Regulatory Bodies	0.02	0.08	0.01	0.01	0.01	0.03	0.02	6.2
Total							0.9 ≡ 1	λ_{Max} = 6.36

$CR = \frac{CI}{RI}$, *n =6* corresponds to 1.24 from Saaty's Random index (RI) Table

$$CR = \frac{0.072}{1.24}$$

$$CR = 0.05 \leq 0.10.$$

The consistency ratio of $CI = 0.05 \leq 0.10$ suggests the decision makers judgement are generally consistent and reliable for decision making.

DOI: 10.64290/bimagombe.v9i2A.1065

Table 17 shows the ranking of Stakeholder perception on the most influential Smart campus Stakeholder

Table 17: Ranking of Stakeholder perception on the most influential Smart campus Stakeholder.

Stakeholders	Criteria Weights	Ranking
Student	0.45	6
Academic Staff	0.21	5
Non-Academic Staff	0.09	3
Management Team	0.12	4
Vendors	0.05	2
Regulatory Bodies	0.04	1

Ranking of Stakeholder perception base on Impact on Smart Campus Operation is shown in Table 18.

Table 18: Ranking of Stakeholder perception base on Impact on Smart Campus Operation.

Stakeholders	Criteria Weights	Ranking
Student	0.35	6
Academic Staff	0.23	5
Non-Academic Staff	0.09	3
Management Team	0.14	4
Vendors	0.06	2
Regulatory Bodies	0.05	1

Table 19 shows the ranking of Stakeholder perception base Dependency of the Campus on the Stakeholder.

Table 19: Ranking of Stakeholder perception base Dependency of the Campus on the Stakeholder.

Stakeholders	Criteria Weights	Ranking
Student	0.27	6
Academic Staff	0.27	6
Non-Academic Staff	0.08	4
Management Team	0.26	5
Vendors	0.04	3
Regulatory Bodies	0.02	2

Table 20 shows the ranking of stakeholder perception base on smart campus Engagement

Table 20: Ranking of Stakeholder perception base on Campus Engagement.

Stakeholders	Criteria Weight	Ranking
Student	0.21	5
Academic Staff	0.42	6
Non-Academic Staff	0.06	3
Management Team	0.09	4
Vendors	0.1	2
Regulatory Bodies	0.02	1

DISCUSSION

The study focused on developing a model to predict the perception of university stakeholders toward a smart campus, emphasizing a human-centered, learning-oriented model. The identified stakeholders included students, academic staff, the management team, non-academic staff, vendors (technology providers and system integrators), and regulatory bodies. The research employed the AHP to evaluate stakeholders' roles based on four criteria: influence on campus, dependency of the campus on the stakeholder, engagement of the stakeholder, and impact of the stakeholder on campus.

Through pairwise comparison, students were identified as the most influential stakeholders, followed by academic staff and the management team. Similarly, students, academic staff, and the management team ranked highest in their impact on the campus.

In terms of dependency, students and academic staff shared the highest weight (0.27), with the management team following. Regarding engagement, academic staff ranked the highest (0.42), followed by students (0.21) and the management team (0.09). Non-academic staff, vendors, and regulatory bodies consistently ranked lower

DOI: 10.64290/bimagombe.v9i2A.1065

across all criteria. The results were verified using a consistency ratio (CR $\leq$ 0.1), indicating reliability and suitability for decision-making processes.

CONCLUSION

The study successfully developed a robust model for assessing and prioritizing university stakeholders in the context of a smart campus. It demonstrated that students and academic staff are important stakeholders due to their significant influence, impact, and engagement on campus activities. While management teams also play a crucial role, other stakeholders such as non-academic staff, vendors, and regulatory bodies were found to have comparatively lower involvement or impact. These findings underscore the importance of focusing on primary stakeholders, especially students and academic staff, in designing and implementing smart campus initiatives.

Recommendation For Further Work

1. Strategic Focus on Primary Stakeholders: Decision-makers should prioritize students and academic staff in the planning and deployment of smart campus projects, ensuring their needs and preferences are central to the model.
2. Enhanced Engagement Programs: Universities should foster greater engagement among non-academic staff, vendors, and regulatory bodies to ensure a holistic approach to smart campus development.
3. Tailored Policies and Investments: Resource allocation and policy formulation should reflect the varying levels of influence and engagement of different stakeholder groups, with a higher emphasis on students and academic staff.
4. Continuous Stakeholder Assessment: Universities should regularly reassess stakeholder perceptions and roles to adapt to changing dynamics in smart campus development.
5. Collaboration with Vendors and Regulatory Bodies: Strengthen partnerships with vendors and regulatory bodies to leverage their technical expertise and align regulatory standards with the institution's goals.

This model offers a structured approach for universities to enhance stakeholder inclusion and optimize the development of smart campus systems.

Future work

Although vendors and technology providers were considered as stakeholders, the study did not delve deeply into the technological infrastructure or innovations necessary for a smart campus, future studies should consider the inclusion of technological infrastructure which could have further enriched the model. Also, other external stakeholders, such as alumni, industry partners, and community members, should be considered for future studies.

By adopting these recommendations, future research could build upon the successes and challenges of this study, contributing to more inclusive, accurate, and culturally relevant ethnicity classification models. Future research should focus on expanding datasets, exploring innovative architectures, optimizing for real-world applications, integrating ethical best practices, and investigating broader applications of ethnicity classification. By following these recommendations, researchers can create more accurate, fair, and socially responsible models, ultimately advancing the role of AI in fostering inclusive technology that respects and reflects the diversity of human populations.

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