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INDICATORS AND DIMENSIONS IN THE FORMULATION AND EVALUATION OF A SUSTAINABLE CAMPUS INDEX

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Abstract

The establishment of a green campus assumes significance in ensuring comfort and elevating the overall quality of life. This study was conducted to ascertain the variability in the questionnaires and delineate the attributes of questions exhibiting high variation in the results. Therefore, constructing the UniSZA Green Campus index based on the acquired weighted values. A total of 420 questionnaires were returned out of 500. Principal Component Analysis was employed to extract distinctive information from the amalgamated dataset. The results of the analysis draw out four factors that were discerned and subsequently interpreted as environmental management (46.65%), environmental infrastructure (12.53%), environmental atmosphere (6.35%), and environmental program (5.39%). In assessing the variation of the UniSZA Green Campus Index, distinct categories were identified, encompassing excellent, good, fair, poor, and bad classifications. This study suggests that the average UniSZA Green Campus index is situated within the second category. Despite the indication of good standing, the university should proactively take steps to ensure that UniSZA aligns with the principles of environmental sustainability in daily practices. The index system can serve as a guide for universities to attain sustainability on their campuses.

Keywords: Environment; Green campus; Sustainable; UniSZA Green Campus Index

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INTRODUCTION

The discourse on sustainability has been a focal point of deliberations in numerous international conferences of global significance (Hisham et al., 2023; Rwelamila & Purushottam, 2015). The promulgation of the sustainable development paradigm transpires through the conveyance of information, fostering an understanding of the imperative for equilibrium among the environment, economy, and society (Abakumov & Beresten, 2023). The concept of sustainable development has imposed fresh requisites for engagement from higher education institutions, positioning universities as pivotal entities in spearheading transformative change and progress. Consequently, they function as a nexus between scientific knowledge and practical wisdom (Pereira Ribeiro et al., 2021). The concept of sustainability in higher education was initially introduced in the Stockholm Declaration of 1972, forging a connection between humanity and the environment while acknowledging their interdependence in attaining environmental sustainability (Dawodu et al., 2022). The endeavour toward establishing a green campus has garnered significant attention from the university community, especially in the aftermath of the Sustainability in Higher Education declaration (Tan et al., 2014). In response to the imperative of environmental sustainability, universities have commenced the integration of measures spanning education, research, university operations, and administration. This comprehensive approach includes the oversight of green buildings, energy, water, food, transportation, purchasing, waste, and the implementation of sustainable landscaping practices (Rwelamila & Purushottam, 2015).

The Green Campus Initiatives encompass educational efforts in sustainable development and the integration of eco-friendly infrastructures within university campuses (Gomez & Yin Yin, 2019). The awareness of green practices in society has been extensively studied in the context of environmental practices. Certain studies have introduced a sustainability framework tailored for university campus societies, aiming to transition towards a Green campus and thereby promote a healthier environment for the campus community, with a specific emphasis on enhancing the economic, social, and environmental quality of life for university community (Anthony Jnr, 2021). The concept of a green campus is conceived to advance sustainable development within tertiary education institutions. Aligned with the Malaysian government's support for the establishment of green university campuses in the nation, several Malaysian universities have commenced the adoption of diverse green practices. These initiatives involve the implementation of various strategies aimed at fostering sustainable practices (Anthony Jnr, 2021).

The UI GreenMetric, introduced by Universitas Indonesia in 2010, primarily assesses universities using specific criteria and indicators designed to

ensure the environmental sustainability of higher educational institutions, aiming to create a global ranking based on universities' sustainable practices (Suwartha & Sari, 2013). The UI GreenMetric World University Ranking establishes its six primary criteria based on information provided by respective universities, showcasing their dedication to environmentally sustainable practices. These criteria encompass environmental settings and infrastructure, energy and climate change efforts, waste management practices, water usage policies, transportation initiatives, and environmental education programs (Atici et al., 2021). The six principal criteria of the UI GreenMetric Ranking are founded on sustainability practices, the successful implementation of which is anticipated to yield a favourable impact on the quality of life (QOL). Previous study stated that enhancing the quality of life for the university community is essential to underpinning the mindset of the entire university community in effectively implementing the sustainable development policy for a green campus (Tiyarattanachai & Hollmann, 2016). The concept of quality of life is multifaceted and may lack a precise definition, encompassing notions such as well-being, satisfaction, and happiness (Bakaruddin & Idris, 2022). Nevertheless, the aspiration for a green university initiative may not be universally suitable if the universities are not adequately prepared for its implementation.

In contemporary research, diverse statistical techniques are employed to assess and comprehend intricate datasets for enhanced understanding. Statistical methodologies, including principal component analysis, are frequently utilized to delve into the data, facilitating the identification of potential factors influencing datasets (Fazillah et al., 2022). As of now, there is a scarcity of reported studies employing multivariate statistical techniques in green campus research. Consequently, this study puts forth a standardized multivariate analysis method, specifically principal component analysis, to accurately decipher the data and derive optimal insights about the green campus aspect. Drawing upon a study conducted by Abdullah et al., 2021, which utilized PCA to formulate an index, the current study adopted similar procedures to generate a green campus index for UniSZA.

This paper aims to delineate the significance of different criteria in evaluating the levels of achievement in green university campuses in Malaysia. The findings also contribute to the formulation of the UniSZA Green Campus Index for assessing the green campus status at UniSZA. Hence, the primary objective of this study was to scrutinize the perceptions held by the university community concerning their quality of life. The objective was to investigate if a Green Campus university, demonstrating exemplary performance across the six primary criteria of the UI GreenMetric World University Ranking, indeed had positive effects on the QOL of its resident university stakeholders.

RESEARCH METHODOLOGY

Study Setting

This study employs a quantitative approach utilizing primary data collection through the administration of a questionnaire. This research was conducted at Universiti Sultan Zainal Abidin (UniSZA) and the study sample was the university community. The utilized questionnaire focused on sociodemographic information, and addressed elements related to a green campus and the respondents' perceptions of quality of life. The responses were measured using the five Likert Scale and sorted in ascending order ranging from 1 (strongly disagree) to 5 (strongly agree). A Google form tool was used as a channel to distribute the questionnaire at the university. A link to the web-based survey was sent through the email and WhatsApp application. No incentive was provided to the respondents for completing the questionnaires. The study successfully obtained responses from 420 participants within the 5-month data collection period who were randomly selected. The number of samples collected conformed to the anticipated sample group size.

Data Analysis

Dimensionality of Data

In this study, principal Component Analysis was utilized to discern the variability within the dataset and uncover concealed features within its complexity to ascertain the factors that exert a noteworthy impact on the environmentally sustainable practices within the university campus (Gupta et al., 2018). Hence, developing a UniSZA Green Campus University. PCA is a technique employed to manage extensive and intricate datasets, transforming them into meaningful representations. This method involves scrutinizing the data to produce a lower-dimensional linear structure. The PCs can be expressed as:

$$z_{ij} = a_{i1}x_{1j} + a_{i2}x_{2j} + \ldots + a_{im}x_{mj} \quad (1)$$

Where z is the component score, a is the component loading, x is the measured value of the variable, i is the component number, j is the sample number and m is the total number of variables.

The Establishment of UniSZA Green Campus Index

Each factor can be considered as a dimension within the broader context of the green campus framework. Hence, the scores of each factor can serve as a singular index, signifying the specific aspect to which the factor is linked. A green campus index is formulated using the methodology outlined by (Li & Weng, 2007). The comprehensive score for each participant is derived through the application of weights to individual factor scores, taking into account their respective variances.

In the course of this investigation, the green campus index for UNISZA is constructed by assigning weights to the dimensions based on the variance of their corresponding factors. The formulation of a UniSZA Green Campus Index (UniSZA GCI) necessitated the amalgamation of four distinct factors, each emblematic of various facets of a sustainable campus environment. Each factor positively contributes to the overall quality of life for university community. The cumulative score for each category was subsequently derived by summing the weighted factor scores of the four elements through the equation provided below:

$$UniSZA\ GCI = \sum_i^n F_1\, W_i \qquad (2)$$

In the context of this study, where n represents the number of selected factors, F_1 denotes the i score of the factor, and variance w_i signifies the percentage of variance explained by the factor i. The cumulative score, computed through the application of equation 1, exhibits a range spanning from -212.763 to 66.154. The index values encompass both negative and positive values, which were recalibrated into z-values (transformed to a new, smaller scale to ensure unity variance for each variable) through the application of the following equation:

$$Rescaling\ (1\ to\ 100) = a + \left((xi - A)\ X\ (b - a)/(B - A)\right) \qquad (3)$$

where a is equal to 1, xi is the actual observation, A and B are the lowest and highest factor scores, respectively, and b is a constant with a value of 100.

RESULT AND DISCUSSION

The Socio-demographic Profile of University Residences

The entirety of the participants consisted of individuals who were Malays (100%) and adherents of the Muslim faith. Study participants were predominantly female (70.71%) with an average age of 18-24 years. The majority of respondents (99.29%) possessed a commendable level of education, signifying their enrolment or attainment of higher education qualifications. While a considerable portion of the respondents (68.57%) has not undergone formal environmental coursework, more than half of them (69.29%) have participated in environmental programs organized either on-campus or off-campus. Figure 1 illustrates the socio-demographic composition of the study sample.

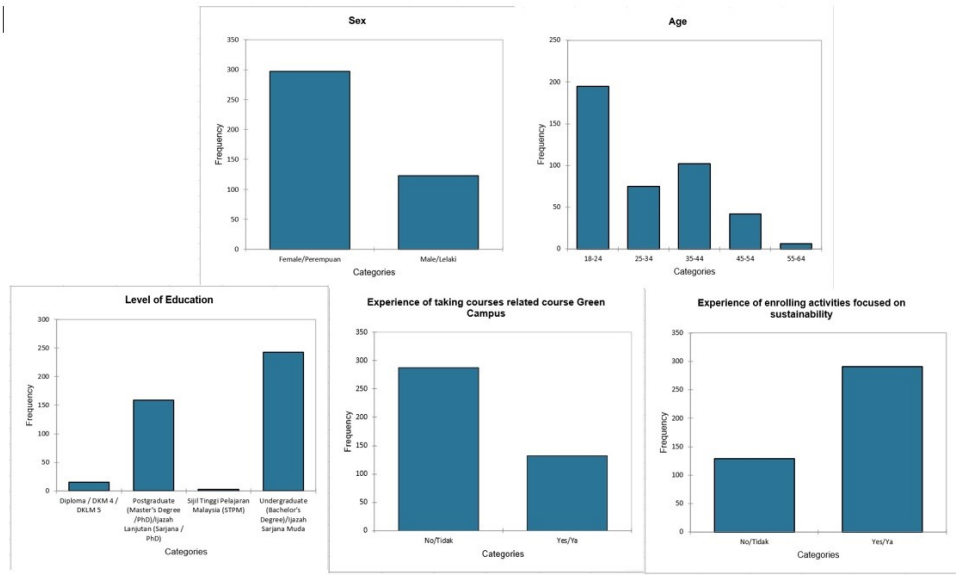

Figure 1: The socio-demographic composition of the study sample

Variations of the answer given by university community

Summary statistics for the answers given by university community in the study area are presented in Figure 2. The majority of questions displayed limited variation in the provided responses, as evidenced by small standard deviations. However, question 4 exhibited the highest variation among all questions, suggesting a more dispersed range of responses from the university community. The high variation of answer given for SB4 (1.013), SB2 (0.975), SB13 (0.866), SB20 (0.814), SB18 (0.799), SB19 (0.796), SB17 (0.786), and SB11 (0.753) suggests that the realization of the green campus aspect was not achieved by the university community. Additionally, a majority of them were not aware of the implementation of a green campus in the university. Consequently, this study recommends the necessity to promote and enhance education on green campuses. With the exception of SB1, all questions exhibit considerable variability. Question SB1 exhibits the smallest box plot length, corresponding to the lowest standard deviation value of 0.48. This implies that, on the whole, respondents hold the belief that environmental management is crucial for the university's campus.

Question SB3 and SB14 asking about the importance of green campus shows not significantly different since the mean score for SB3 is 4.54 and SB14 is 4.24. most of them agreed that green campus might enhance the QOL. A campus designed as a green campus has the potential to offer comfort to its users, contributing to an enhanced perception of their QOL. In line with this study,

Tiyarattanachai & Hollmann, (2016) and McFarland et al. (2008) indicated findings demonstrated that the community within the university's green campus exhibited higher satisfaction levels and experienced a significantly improved quality of life.

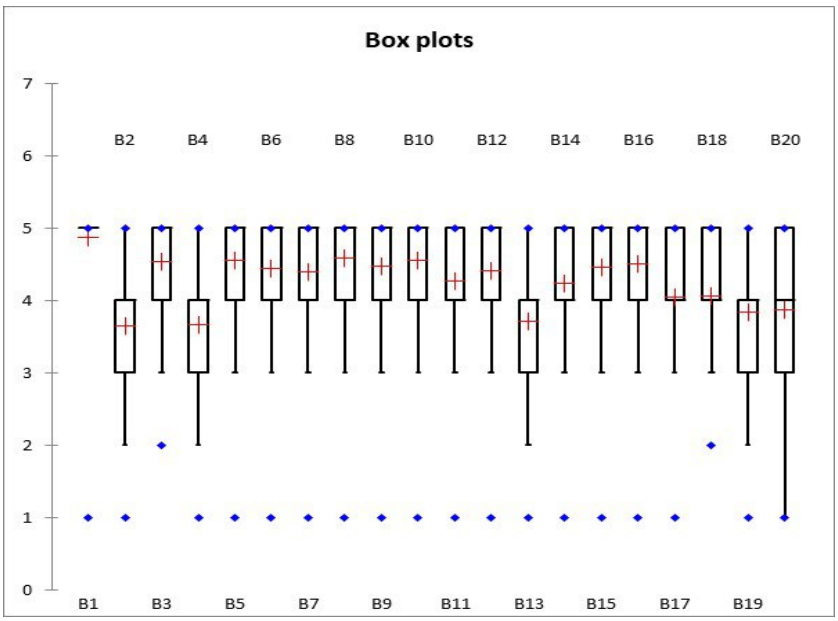

Figure 2: Box Plot explains the variability of question among UniSZA Resident

Determination Characteristics of Green University Campus Criteria on Quality of Life

Before performing PCA, an evaluation of the KMO measure and Bartlett's sphericity test was conducted on the parameter correlation matrix to assess the appropriateness and validity of employing PCA in the given context. The KMO result was 0.90 and Bartlett's test was significant ($p<0.0001$), which indicated the validated use of PCA. The noteworthy Principal Components (PCs) were the factors that clarified the greatest extent of variability observed in the impact of the green university campus aspects on the university residence. A total of four significant Principal Components (PCs), each exhibiting an eigenvalue greater than 1, were extracted from the variables. This contributed to a cumulative explained variance of 70.91%. The variances explained by the individual PCs were 46.65% for PC1, 12.53% for PC2, 6.35% for PC3, and 5.40% for PC4. The first two PCs were the most significant, explaining a total of 59.17% of the variance in the data. The remainder of PCs did not reveal any significant similarities among answers given by the university community.

The present study employed PCA to assess the main influences of a green university campus aspects on the well-being of the university community in the study area. Table 1 presents the outcomes of the varimax rotated factor analysis concerning the quality of life of the university community regarding to the green campus aspects. Four major components with eigenvalues greater than 1 were identified with a total variance of 70.91%. Interpreting factor loadings plays a pivotal role in PCA. These loadings serve as indicators of the associations between variables and factors. Typically, the PC loadings are organized based on the criteria of strength, moderation, and weakness, aligning with absolute loading values exceeding 0.75, within the range of 0.75–0.50, and falling between 0.50–0.30, respectively. The interpretation of the four factors serves to delineate the dimensions of green campus criteria in the following manner:

Table 1: Factor loadings after Varimax rotation from PCA

	EM	EI	EA	EP
B1				
B2		0.824		
B3			0.767	
B4		0.788		
B5				
B6				
B7				0.831
B8				0.755
B9	0.848			
B10	0.769			
B11				
B12	0.776			
B13		0.859		
B14			0.780	
B15				
B16				
B17				
B18				
B19				
B20				
Eigenvalue	9.329	2.505	1.269	1.079
Variability (%)	46.647	12.525	6.345	5.396
Cumulative %	46.647	59.173	65.517	70.913

Extraction method: principal component analysis
Rotation method: varimax with Kaiser normalization
EM: environmental management
EI: environmental infrastructure
EA: environmental atmosphere
EP: environmental program

Factor 1 exhibits strong positive loadings (exceeding 0.8) on three variables: SB9 (0.85), SB10 (0.77), and SB12 (0.78). Factor 1 is linked to environmental management since SB9 and SB10 focusing on university's management on waste and water, while SB12 academic courses and activities related to environmental issues. Environmental management including water management and solid waste management are the criteria of green indicator (Darus et al., 2009). The goal of implementing water and solid waste management is to decrease the production of waste. In the context of practical implementation for managing food waste on the university campus, the waste disposal system on campus can convert food leftovers into compost, consequently diminishing the volume of waste sent to landfills (Kamarudin et al., 2020; Anthony Jnr, 2021). It is essential to address the management of wastes produced during university campus operations by integrating waste recycling. This process entails recovering unwanted materials through reuse, either for alternative purposes or their original intended use (Sugiarto et al., 2022; Md Zain et al., 2012).

Alternative research contends that achieving sustainability and directing environmental management involves various aspects, such as initiatives related to environmental protection, education, and active participation of students (Tan et al., 2014). Via environmental education, residents of university develop a heightened interest in sustainability, actively engaging in resolving environmental challenges. Consequently, there arises a necessity for comprehensive sustainability plans that encompass educational elements for the sustainable advancement of universities (Denan et al., 2018; Choi et al., 2017). A higher score on factor 1 implies an enhanced quality of life for university community in the realm of environmental management.

Factor 2 is distinguished by substantial positive loadings on SB2 (0.82), SB4 (0.79), and SB13 (0.86). The questions lie into this factor related to the infrastructure of university. Consequently, its interpretation aligns with environmental infrastructure, indicating the contentment of university community with the green infrastructure within the university. Establishing an enabling infrastructure for university community is crucial for attaining the development of a green campus (Yusoff et al., 2020; Tan et al., 2014).

An effective infrastructure offered by the university serves as a key component in the institution's pursuit of sustainability (Abakumov & Beresten, 2023). Cultivating a supportive infrastructure serves as a strategic approach to realizing Sustainable Campuses, aiming to streamline the development of an energy and resource-efficient campus through the reduction of energy consumption (Sugiarto et al., 2022; Tan et al., 2014). The implementable components of the university's green campus infrastructure encompass amenities such as bicycle parking, distinct receptacles for various waste categories, initiatives addressing food and waste management, utilization of energy-efficient

technologies, and programs aimed at reducing the consumption of paper and plastic packaging (Abakumov & Beresten, 2023). According to this study, the attainment of a green and sustainable campus requires that the provided infrastructure meets specified quality standards.

Factor 3 can be understood as reflecting the environmental atmosphere. This factor exhibits a substantial loading on SB3 (0.77) and SB14 (0.78), indicating the environmental atmosphere at the university. This query pertains to the criterion of a green campus as the primary factor that distinguishes a campus as a preferred choice. Another study asserted that initiatives for a Green campus encompass the management of green buildings, energy, water, food, transportation, purchasing, waste, and sustainable landscaping (Rwelamila & Purushottam, 2015). The construction of a campus environment should aspire to the goal of being resource-saving and environmentally friendly (Wang et al., 2014). As an integral aspect of the environmental setting and infrastructure criterion, universities are expected to furnish ample green spaces within their campuses. The roles of green campus have the capacity to contribute to an enhanced quality of life for university community. This is supported by study in 2008, Concluded that residents of the university perceive green spaces to exert a positive influence on their Quality of Life (McFarland et al., 2008).

Factor 4 demonstrates a noteworthy positive loading on SB7 (0.83) and SB8 (0.76). The query within this domain pertains to the university's management program for climate change mitigation and solid waste management. Numerous scholarly investigations have delineated climate change as a crucial consideration in the endeavour to cultivate a sustainable and eco-friendly campus environment (Helferty & Clarke, 2009). By implementing waste management programs, including practices like waste separation and reduction, universities have actively endeavored to enhance their dedication to advancing education and research in the sphere of sustainable development (Tan et al., 2014). Execute sustainable education initiatives encompassing waste management and climate change programs, with the objective of equipping university students with essential skills to confront environmental challenges while fostering an enduring appreciation for the environment (Mebane et al., 2023; Suwartha & Sari, 2013). This factor can be interpreted as environmental program.

Within this investigation, Principal Component Analysis (PCA) yielded substantial data reduction, where 10 questions, constituting approximately 50% of the total 30 questions, elucidated 70% of the variance in the data. PCA functioned as a tool to pinpoint these specific questions, showcasing their significant contribution to the green campus dimension among university community.

UniSZA Green Campus Index

The construction of the UniSZA Green Campus Index (UniSZA GCI) entailed the application of univariate clustering, which was then classified into five discrete groups, excellent, good, fair, poor and bad. The highest value of the UniSZA Green Campus Index signifies the optimal quality of life concerning the green campus aspect, whereas the lowest value of the UniSZA Green Campus Index reflects the least favourable level of quality of life in relation to the green campus aspect. The index categories of UniSZA GCI as elaborated below.

Excellent UniSZA GCI: The weightage value for this category ranges from 24.921 to 66.154. The highest value of UniSZA GCI demonstrates that the UniSZA has excellent green campus aspects. About 41.43% of UniSZA residents have excellent UniSZA GCI. The second index category is Good UniSZA GCI. The numerical range for this category spans from -5.663 to 22.692, with approximately 20.71% of the study sample demonstrating a favourable UniSZA GCI. The fair UniSZA GCI with the weighting value for this category ranges from -44.113 to -9.431, encompassing 27.86% of the study sample. This category has moderate level of green campus index. The poor UniSZA GCI implies the scores varied within the range of -117.361 to -46.727, constituting 6% of the study sample. The lowest index is bad UniSZA GCI whereas, the scores exhibited variation in the span of -212.763 to -152.768, comprising 3.57% of the study sample. The picture of UniSZA GCI is presented in Figure 3.

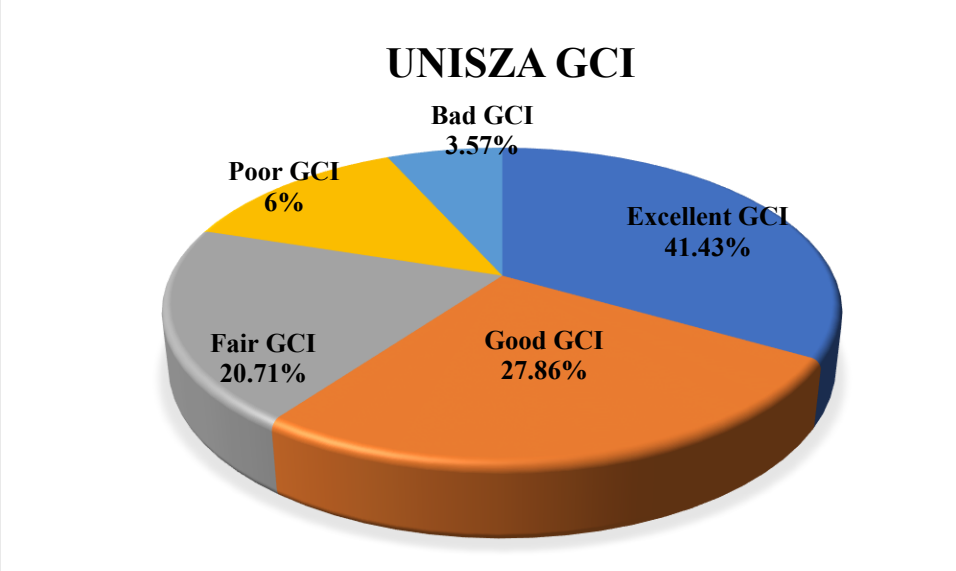

Figure 3: Percentage of UniSZA GCI based on categories.

The creation of such an index typically involves identifying and assessing diverse factors, which may encompass environmental management, environmental infrastructure, the environmental atmosphere, and environmental programs. From the study, we can conclude that the average of UniSZA GCI is Good. The UniSZA Green Campus Index encompasses a thorough framework designed to evaluate and quantify the university's sustainability initiatives and practices comprehensively. This index functions as a metric to measure the university's dedication to environmental stewardship and the formulation adoption of sustainable practices.

CONCLUSION

The concept of a green campus is built upon various variables. This study specifically concentrates on four crucial variables deemed significant and influential in the QOL of the university community. These variables include environmental management, environmental infrastructure, environmental atmosphere, and environmental programs, all identified as factors impacting the QOL of the university community. Implementing the principles of green campus design is recommended for enhancing the overall quality of life on the campus. The creation of the UniSZA Green Campus Index has resulted in the categorization of indexes as excellent, good, fair, poor, and bad.

These categories serve as indicators to ascertain the level of the green campus index at UniSZA. This study suggests that commencing the UniSZA Green Campus Index necessitates a methodical approach. In association with this index, continuous monitoring and periodic assessments are crucial for tracking advancements and pinpointing areas that warrant ongoing enhancement. This iterative process underscores the university's steadfast commitment to advancing sustainability objectives and making substantial contributions to the wider dialogue on environmentally responsible campus management.

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