A SPATIAL DATA FRAMEWORK FOR ASSESSING CAMPUS IN NIGERIAN HIGHER INSTITUTIONS THROUGH SOCIAL MEDIA ANALYTICS

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A Spatial Data Framework for Assessing Campus in Nigerian Higher Institutions through Social Media Analytics

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgment has been made in the text.

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ADENLE Yusuf Adetunji (Name of student)

DEDICATION

This thesis is dedicated to my father for ensuring that I attain the peak of my academic career.

ABSTRACT

Sustainable campus development has gained several policymakers and urban planners' attention within the past decades, with different campuses of higher education institutions (HEIs) across the world claiming to be sustainable or have adopted initiatives of becoming sustainable. Also, different scholars at universities, non-governmental, country-level in addition to the United Nations Environment Programme (UNDP) have established toolkits, ratings, models, and frameworks for the appraisal, evaluation, monitoring, and tracking the level of environmental, social, economic, and institutional sustainability in the campuses of HEIs. HEIs decision-makers can utilize the outputs of such campus sustainability appraisal (CSA) to evaluate the accomplishment of their policies and campus-wide action plans, improvement in campus, livability, quality of life (QOL), and direction for future development in different parts of the world. However, the different tools for assessing sustainability in campuses of HEIs cannot be utilized in all institutions across the globe due to factors such as regional variation. A comprehensive review of extant literature also reveals a knowledge gap on the sustainability impacts of the physical environment and spatial settings of campuses of HEIs, unlike the socio-economic dimensions.

Therefore, this research aims at developing an innovative campus-wide, spatial, and environmental-dimension sustainability indicators framework for the appraisal and visualization of sustainability performance within the campuses of HEIs in Nigeria (a paradigm shift from the existing studies and approaches). The goals are to (i) set up performance-based spatial indicators via social media user-generated content (UGC) to appraise campus-wide sustainability and advance QOL and livability and (ii) visualize the outcomes using spatial technology. A literature review also reveals that studies utilizing social media data and or big data analysis tool to ascertain the peculiar sustainability indicators of the geographical locations where CSA techniques are being implemented has not been conducted before. This is despite the fact that some of the sustainable development goals (SDGs) target information and communication technology (ITC). Besides, despite the challenges of the absence,

inadequate of or restrained access to necessary information for CSA exercise in the global south, integrating spatial techniques and software into environmental-dimension indicators with campus-wide and spatial attributes has not been extensively utilized.

Specifically, the research objectives are as follows: (1) identifies the campus sustainability categories that reflect and match the nature of Nigeria HEIs campuses (2) identifies indicators appropriate to appraise the identified categories (3) establishes a practical measurement mechanism to appraise each sustainability category and spatial-based indicator (4) determine and verify the relative importance of each category and indicator and assign them the appropriate weight (5) propose a framework that represents the linkage among the attributes (categories and indicators) in the form of a spatial data infrastructure model based on the Nigeria campus sustainability challenges (6) test the proposed model by applying it to appraise a selected campus in Nigeria via spatial strategy concept.

To achieve the stated goals and objectives, the following research activities and tasks were carried out. First, a comprehensive review of extant literature was conducted to determine the contemporary and up-to-date studies on sustainable campus development. This review process was followed by an extensive analysis of the extant CSA tools leading to (i) identifying their strengths, weaknesses, and absence of their utilization in Nigeria, and (ii) identifying various environmental-dimension sustainability attributes with campus-wide and spatial indicators as a base case for the proposed model. This research phase resulted in an elementary catalog/checklist of campus-wide sustainability attributes that are specific, measurable, achievable, relevant, and time-bound indicators.

The proposed framework integrating and relating the identified campus-wide sustainability attribute and indicators in a hierarchical linkage was developed by considering the needs of campus neighborhoods of HEIs in Nigeria and its sustainability goals based on a novel big data analysis/social media approach. The proposed framework and the identified attributes and indicators were verified and validated by local experts. After that, the experts were consulted to prioritize each category and indicator, and the analytic hierarchy process (AHP) was utilized to assign weights.

Measurement components of each campus-wide and spatial-dimension indicator were established to allow for CSA exercise using geographic information systems (GIS) technology spatial strategy and analysis toolkits for sustainability analysis. Based on spatial data that include vector data, raster data, aerial/satellite imagery, attributes data, and metadata, the proposed framework, was test-run and validated using one of the campuses of HEIs in Nigeria. Sustainable campus planning and spatial strategy principles and policies were recommended. Finally, inputs and feedback on the final model was received from both local and international experts.

The outcomes of the study is of enormous benefit to HEIs in Nigeria in many ways relating to but not limited to (i) enhancing campus livability, QOL and encourage the rise in human health via the adoption of environmentally friendly developmental policies and actions (ii) promoting campus sustainability and livability practices via the adoption and modification of the proposed model for sustainability appraisal, and (iii) improving the efficiency of campus-wide environment developmental policies.

PUBLICATIONS

Some of the chapters of this thesis have been extensively and partly published in this research list.

Journal Papers

1. **Adenle, Y. A.**; Chan, E. H. W.; Sun, Y.; Chau, C. K. Assessing the Relative Importance of Sustainability Indicators for Smart Campuses: A Case of Higher Education Institutions in Nigeria. *Environ. Sustain. Indic.* **2021**, *9* (December 2020), 1–7. https://doi.org/10.1016/j.indic.2020.100092.
2. **Adenle, Y. A.**; Chan, E. H. W.; Sun, Y.; Chau, C. K. Modifiable Campus-Wide Appraisal Model (MOCAM) for Sustainability in Higher Education Institutions. Sustain. 2020, 12 (17). https://doi.org/10.3390/SU12176821.
3. **Adenle, Y. A.**; Chan, E. H. W.; Sun, Y.; Chau, C. K. Exploring the Coverage of Environmental-Dimension Indicators in Existing Campus Sustainability Appraisal Tools. *Environ. Sustain. Indic.* **2020**, *8* (August), 1–11. https://doi.org/10.1016/j.indic.2020.100057.
4. **Adenle, Yusuf A.**, Abdul-Rahman, M., Soyinka, O.A., 2021. Exploring the usage of social media in extant campus sustainability assessment frameworks for sustainable campus development. Int. J. Sustain. High. Educ. https://doi.org/10.1108/IJSHE-03-2021-0091
5. **Adenle, Y. A.**; Chan, E. H. W. Exploring the Utilization of Theoretical Basis in Existing Campus Sustainability Appraisal Tools. International Journal of Higher Education and Sustainability Vol. 3, No. 3, **2021, DOI**: 10.1504/IJHES.2021.117872

Journal Papers Under Review

1. Appraisal of Campus-wide Environmental Sustainability Indicators in the Context of National Spatial Strategies: Case Study of a Nigerian University. *Sustainability*

Conference Papers

1. **Adenle, Y. A.**; Chan, E. H. W.; Sun, Y.; Chau, C. K. Campus Sustainability Appraisal in Nigeria: Setting up Sustainable Attributes for Higher Educational Institutions. REAL CORP 2020, Shaping Urban Change Livable City Regions for the 21st Century, 15-18 September 2020. https://programm.corp.at/cdrom2020/papers2020/CORP2020_81.pdf
2. **Yusuf A. Adenle,** XU Pengpeng, C.K. Chau, H. Visscher4 and Edwin H.W. Chan. An Approach to Assessing Campus Sustainability Indicators Level of Importance Using Social Media Data – A Case of Nigeria. CRIOCM 2019 - The 24th International Symposium on Advancement of Construction Management and Real Estate, Nov. 2019, Chongqing

Pending submission

1. Appraising Quality of Life in Higher Education Institutions: Toward the Development of a Modifiable Approach. *Sustainable Development*

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CHAPTER 1: INTRODUCTION[1]

1.1 Chapter Overview

This chapter explores the diverse components concerned with contextualizing and appraising the campus-wide environmental sustainability indicators with spatial dimension for QOL within the context of HEIs campuses. In establishing local-based sustainability indicators encompassing the Nigerian dynamic and allowing the different comparisons amongst the HEIs, the chapter extensively reviewed conceptual frameworks and methods relating to appraisal and tracking of sustainability for QOL and livability. This contextualization led to this study's (i) research aim and objectives and (ii) development of a multi-dimensional and multi-criteria appraisal framework in assessing sustainability for QOL in the campuses of Nigerian HEIs. The outcomes reveal the need for an adaptable/modifiable approach incorporating (i) top-down and bottom-up approach (ii) social media, webpage, and existing campus sustainability appraisal (CSA) tools' document as sources of data, and (iii) quantitative and qualitative data analysis. The thesis structure is also presented in this chapter.

1.2 Background

QOL and livability can be referred to as the comprehensive health, comfort, welfare, etc., of humans within the immediate environment they reside. Urban planning is one of the fields where the relevant concept of QOL has been acknowledged since its conception in the 1940s. The approaches and methodology utilized in addressing QOL and livability in urban planning, social sciences, environmental management, etc., differ among scholars and policymakers. Different scholars are

[1] This chapter is partially based on the following conference papers:

Adenle, Yusuf A., Chan, E. H. W., Sun, Y., & Chau, C. K. (2020). Campus Sustainability Appraisal in Nigeria: Setting up Sustainable Attributes for Higher Educational Institutions. *REAL CORP 2020 Proceedings/Tagungsband 15-18 September 2020* https://archive.corp.at/cdrom2020/papers2020/CORP2020_81.pdf

Yusuf A. Adenle, XU Pengpeng, C.K. Chau, H. Visscher4 and Edwin H.W. Chan. An Approach to Assessing Campus Sustainability Indicators Level of Importance Using Social Media Data – A Case of Nigeria. CRIOCM 2019 - The 24th International Symposium on Advancement of Construction Management and Real Estate, Nov. 2019, Chongqing involved in diverse areas of QOL and livability, ranging from the urban populace's living standard/well-being to human development. Several QOL and livability frameworks and models have been designed by various scholars and the United Nations (UN) to appraise urban dwellers' standard of living, well-being, health, and sustainability.

According to UN statistics, approximately half of the world’s population is expected to live in cities by 2030, with 95% of the city expansion projected to occur in developing countries. Therefore, policymakers' and several stakeholders' concerns, commitment, and involvement in appraising and determining the QOL and livability in cities and urban centers have risen. Cities are focal points for socio-economic development, culture, productivity, creativity as well as smart initiatives. However, this concept has not been fully explored from the HEIs campus perspective. Campuses of HEIs can also be referred to as urban areas or cities at a smaller scale because they possess diverse coverage areas, different land uses, a wide variety of activities, and socio-economic and environmental challenges (Alshuwaikhat & Abubakar, 2008).

Within HEIs campuses, the commencement of QOL/livability studies and related research could be linked with the development of various CSA tools. These tools are developed to monitor and assess different campus developmental project requirements and levels of importance affecting the peoples' lifestyle and well-being. Campus master plan design for sustainability and the strategic sustainability development of HEIs campus neighborhood could also be evaluated using these CSA tools. QOL studies in HEIs have been driven by but not limited to students’ satisfaction (Pedro et al., 2018), intellectual capacity (Pedro et al., 2020), psychosocial conditions (Posadzki et al., 2009), the efficiency of HEIs based on pro-sustainability (Pedro et al., 2021), academic staff quality of working life, and terminal health-related diseases. This vast realm makes studies on QOL and livability an effective, pragmatic, and efficient approach to appraise, monitor, and track the consequences of cultural, socio-economic, environmental development plans, policies, and actions in our campuses of HEIs.

In Nigeria, various government administrations had extensively funded the planning, designing, establishment, and advancement of the nation's HEIs campuses without completely neglecting the students, staff, and other relevant stakeholders' lifestyle and health. However, there exist the absence of a metric system for the appraisal of QOL in its campuses. The tracking and monitoring mechanism for the efficiency of current campus developmental policies and their footprint on those within these institutions is also lagging. The 2009 Abuja Declaration on sustainability in higher education (held in Nigeria) acknowledged that appropriate, substantial awareness and consideration to confronting, tackling, pursuing, communicating, and undertaking the modus operandi relating to sustainability for QOL and livability in the campuses of HEIs in the continent of Africa is unsatisfactory. As such, the 2009 Abuja Declaration on sustainability invigorates African institutions to reassess their education system in terms of QOL, livability, and sustainable development.

In this Introductory Chapter, an extensive literature review and analysis of QOL, livability, and sustainability studies were carried out, representing the study's background and justification. The growth and development of the concept of sustainability, livability, and QOL, as well as the practical methods in developing a local-based campus-wide sustainable spatial indicators appraisal framework within the Nigeria HEIs context, were also examined.

1.2.1 QOL Definitions within HEIs Physical and Spatial Settings

Although QOL is a terminology that is recently gaining the attention of policymakers, the discussion and documentation of humans vying for a quality lifestyle has been in existence since the beginning of time. The emergence of the term QOL could be linked back to the end of the Second World War. During that period in the United States of America (USA), it was mostly used to express the impacts of luxury on humans' health and living standards (Fischler, 2000). This description later received criticism due to material luxury's inability to cover human life's necessary conditions (Chen et al., 2016). During the 1960s, the Social Indicators Movement advanced the studies of QOL to aspects of human life that are socially based (Marans, 2015). Environmental challenges and their associated impacts on humans' health and well-being during the 1960s also created debates and research on environmental QOL. However, the concept of QOL and livability has been incorporated into several industries like Construction and Environment, Health and Wellness, Insurance, and Education (Posadzki et al., 2009). Presently, the concept of QOL and livability has become a universal standard threshold by different countries, regions, cities, municipalities (Al-Qawasmi, 2020), and neighborhoods such as campuses of HEIs.

Topics related to QOL have also increased among academic scholars and various ministries, departments, and government agencies, leading to the multidisciplinary research field in different parts of the world. Several academic branches of knowledge such as psychology, sociology, health, and urban studies have identified the QOL concept's relevance and various definitions and appraisal framework designed to track quality lifestyles across different communities (Al-Qawasmi, 2020). This multidisciplinary nature of QOL has made sustainable development policy decision-making challenging to decision-makers because of the diverse adopted conceptual and methodological frameworks across the disciplines. As such, the development of a QOL and livability appraisal framework incorporating the various sustainability pillars (i.e., socio-economic and environmental attributes) has become the order of the day.

Although establishing a theory of what constitutes a good life is paramount before commencing with the appraisal of sustainability for QOL and livability, the literature review reveals its multiple definitions and interpretations based on research aim, objectives, contextual framework, scope, and purpose despite its diverse utilization. Schalock (2004) believed that what constitutes QOL remains fuzzy and unascertained and, therefore, becomes challenging in coming up with an accurate definition or a measuring mechanism. From the literature, while some scholars opined that QOL is attained when humans are happy or satisfied with their well-being, others believe it is related to humans' society living conditions. As such, a diversity of theories on what represents a good life as well as what accounts for a good, livable, and sustainable HEIs campus setting.

Based on the multiple definitions of QOL, some scholars concluded that a globally recognized definition of the term is not in existence (Al-Qawasmi, 2020; Schalock, 2004). However, these various meanings, definitions, and interpretations are not the limitations of the concept but rather its multidisciplinary and complex nature. Apart from the research aim, objective, contextual framework, scope, and purpose that create different QOL definitions and interpretations, the study's geographical location is another major factor. With the adoption of comparable or related concepts and theories, the utilization of dissimilar or non-related operationalization might create different QOL attributes, indicators, and sub-indicators. As such, the need to contextualize the concept of QOL and livability in campuses of HEIs in Nigeria due to their none existence in the country.

From the exploration of approximately 50 definitions of QOL in the existing literature, two categories were observed. These are objective and subjective definitions. As such, different schools of thought on appraisal and monitoring approaches. While the subjective category concentrates on the human feelings, well-being, perception, and life experience; the second category is towards the objective society's QOL (Al-Qawasmi, 2019), such as the campus neighborhood of HEIs. Despite the variations in QOL definitions, a definition is pertinent and suitable to the appraisal of QOL in the campuses of HEIs due to its identification of geographic location's environmental impacts. It is defined "*as the satisfaction that a person receives from surrounding human and physical conditions*" pg. 729 (Mulligan et al., 2004). In this study, QOL and livability in the campuses of HEIs in Nigeria are approached from their physical and spatial setting based on the above definition.

1.2.2 Quality of Life and Sustainability

Similar to the QOL definitions and interpretations, the literature review also reveals that interconnected, associated, or related QOL concepts are used synonymously despite their distinction. The prominent among these related concepts are (i) standard of living, (ii) well-being, (iii) life satisfaction, (iv) welfare and happiness, and (v) sustainability (Stanković et al., 2017). However, the distinction between these concepts should be identified before conducting campus-wide appraisal in the HEIs campuses to attain improved human QOL and livability.

For instance, the standard of living concept is concerned with how well and how much goods and services are provided to the dwellers residing in a geographic location. This concept is mostly assessed using the society's population/living density, birth and mortality rates, GDP per capita, life expectancy, literacy rate, etc. However, the coverage of sub-indicators, indicators, and categories within QOL is diverse than the standard of living. Also, the concept of well-being refers to the satisfaction or happiness humans attained after their life evaluation. This subjective concept covers a vast dimension of QOL and, as such utilized in most QOL research. For instance, the Organisation for Economic Cooperation and Development (OECD) QOL assessment tool incorporates several indicators that measure well-being (OECD, 2020).

Another prominent concept that is regularly associated with QOL is life satisfaction. During the last four and five decades ago, academic scholars mostly defined QOL experience using the life satisfaction concept. According to Felce and Perry (1995), QOL conceptualization is "*the sum of a range of objective, measurable life conditions experienced by an individual*" and differentiate it from the satisfaction that was referred to as "*subjective responses to such condition*" pg. 54. Hagerty et al. (2001) conceptualize satisfaction as an individual adaptation toward specific life conditions. In this study, the concept of welfare and happiness concerning QOL (Veenhoven, 1991) and livability was also reviewed extensively in the literature.

The last prominent related concept to QOL is sustainability. The sustainability concept established broader dimensions that integrate ideas from sustainable development by the UNDP, Millennium Development Goals (MDGs), and SDGs. Rather than only tracking and appraising well-being via economic growth, well-being is optimized using this concept based on socio-cultural values, human and institutional values, and environmental dimensions within an economy. A society can be referred to as a sustainable society if it provides social, environmental, and economic success. Based on this concept, all that is required to establish an environment and opportunity for people to advance QOL and livability is building a sustainable environment. In this perspective, institutions like politics, families, and schools are given special consideration to implement a sustainable QOL and livability.

Finally, this sustainability concept's essential contribution is placing the three pillars of sustainable development as the primary component of a quality settlement. Definitions from QOL Index based on this concept include but are not limited to: (i) *"the product of the interplay among social, health, economic and environmental conditions which affect human and social development"pg.2* (Shookner, 1998), (ii) *"the general well-being of people and the quality of the environment in which they live"* (The WHOQOL Group, 1995).

In this study, campus-wide sustainability for QOL and livability is appraised based on (i) the above definitions that emphasized people's settlement environmental quality, (ii) environmental-dimension aspects of sustainability and sustainable development concept. Rather than approaching QOL in campuses of HEIs using other prominent concepts, the broader dimensions of QOL utilized in extant indicator-based CSA tools/indexes would be explored in establishing an appraisal framework and measurement in this research study area.

1.3 Problem Statements and Research Motivation

Unlike the previous section and sub-sections that laid the foundation for this study, the identified research gaps and rationale for the proposed research scope, appraisal methods, and systematic procedure were presented in this section.

1.3.1 Sustainability for QOL in HEIs: The Concept of Sense of Place

Despite the absence of specific meaning and definition of what constitutes QOL and livability, findings from literature also reveal justification of lack of consensus. One such justification is the diversity in human lifestyle within campus neighborhoods and the uniqueness of these HEIs communities that create these disparities. The appraisal of campus-wide sustainability for QOL and livability in HEIs campuses requires exploring the link between the physical component and those without a physical presence. This sub-section discusses the sustainability of the QOL principle/concept related to places, settlements or geographic locations, and campus settings.

Within HEIs campus setting, diverse environmental factors with spatial dimensions are simultaneously interacted with by humans. Therefore, the appraisal of campus-wide sustainability for QOL and livability in campus neighborhoods should entail the pillars of sustainable development (social, economic, and environmental) of the campus environment. However, the literature has thoroughly studied the impact of social and economic dimensions on humans' QOL (Al-Qawasmi, 2020). Consequently, there is a knowledge gap on the campus physical environment's aspect and spatial settings and their corresponding impacts on QOL and livability.

In literature, research on sustainability for QOL and livability in urban areas was categorized into three broad types (i.e., A, B, and C) (Rogerson, 1999). The dimension such as the environmental characteristics of places (i.e., HEIs campus) is focused upon in QOL studies under Type-A. For Type C, the individual subjective perception and experience concerning sustainability for QOL within a place (i.e., HEIs campus) are researched. Sustainability for QOL studies based on Type B are investigated with emphasis on both Type A and C. Scholars who adopt Type B are mostly on the study area's objectives characteristics (i.e., HEIs campus) with the collection of the subjective characteristics of importance, preferences, weights, and priorities via questionnaire survey and interview (Rogerson, 1999). As such, the personal subjective perception of sustainability for QOL is also integrated with Type B studies related to the concept of a sense of place. According to Foote & Azaryahu (2009), "*Sense of place refers to the emotive bonds and attachments people develop or experience in particular locations and environments, at scales ranging from the home to the nation.*" It is also used in describing the uniqueness of specific settlements, localities, or geographic locations. In this study, the research scope is limited to the uniqueness within the campus neighborhood of HEIs with Nigeria as a case study.

In comprehending the dynamic concept of sustainability and QOL in campuses of HEIs, their appraisal is, therefore, paramount to be conducted via Type B typology. Notably, examining the campus mechanism based on the interaction of their objective characteristics and subjective assessment. A literature review also shows that the study of human beings' level of satisfaction within their geographical location using only objective attributes and indicators is insufficient (Al-Qawasmi, 2020). In the same vein, extensive priorities on subjective perceptive tend to restrict the capacity for sustainability for QOL and livability research outcomes between diverse geographic locations. Hence, the need to adopt the combined subjective and objective techniques for campus-wide spatial indicators appraisal on sustainability for QOL within the campuses of HEIs in Nigeria. This study proposed a framework incorporating different campus-wide environment dimensions in examining sustainable development principles via objective and subjective methodologies.

1.3.2 Exploration and Operationalization of Campus-wide Environmental Sustainability Dimension

The literature review of sustainability for QOL in HEIs shows a lack of consensus on a systematic procedure in contextualizing sustainability indicators for measuring campus QOL. In ensuring the establishment of an appraisal model as well as the contextualization of campus-wide environmental sustainability indicators with spatial dimension, a systematic procedure was proposed, as shown in **Figure 1.1**.

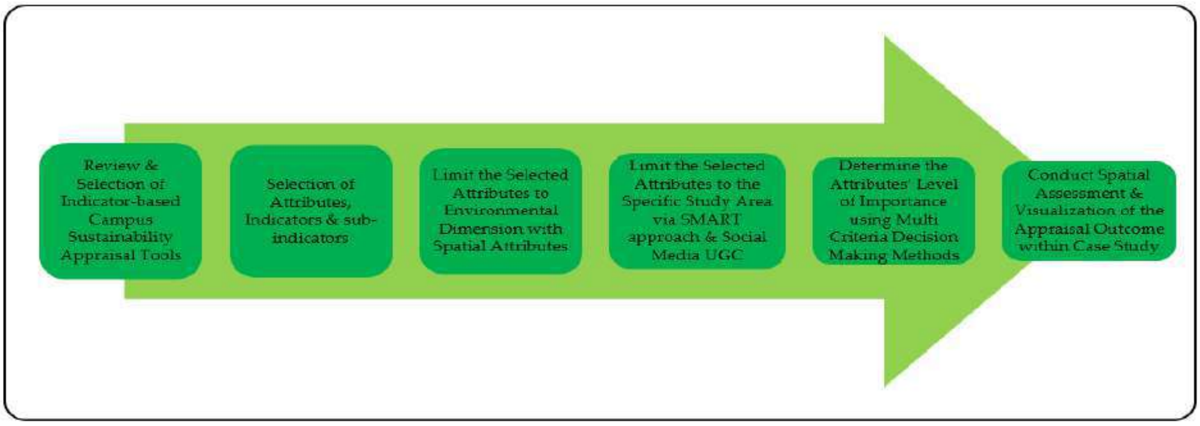


Figure 1. 1: Proposed Procedure for Exploring and Operationalizing Campus-wide Environmental-dimensions

In most cases, the process commences with a comprehensive list of essential attributes (i.e., core domains or main aspects), segregated into indicators and sub-indicators. Using the most used CSA instrument for appraising campus sustainability practices, performance, and QOL in the North American region (i.e., STARS – Sustainability Tracking, Assessment & Rating Systems) as an example, the tool's comprehensive dimension is subdivided into seven categories, 19 indicators, and 69 sub-indicators (STARS Technical Manual, 2019). This subdivision allows for easy allocation of points and operationalization of each indicator and sub-indicators. A framework, conceptual map, or model is mostly used to link/connect the attributes and the indicators. This framework is established to illustrate the interconnection and association that exist between these dimensions.

The framework/model development is the paramount component of the exploration and operationalization process of sustainability for QOL appraisal within the campuses of HEIs in selected geographical regions. Therefore, careful examination, considerations, and analysis are required since the framework conceptualizes, operationalizes, and contextualizes the essential dimensions that will be utilized in line with the appraisal's objective and the study area's demands and uniqueness.

Campus sustainability attributes terminologies and their numbers differ across various CSA tools, scholars, and studies. Despite these variations, the same concept is illustrated in the majority of these studies and tools. There is a need for certain requirements in establishing these attributes before contextualizing sustainability for QOL. Effective and adopted attributes with some specific measures are usually considered for the sustainability of the QOL and livability appraisal framework. Campus sustainability attributes that could not meet these measures/criteria were mostly not nominated. For instance, in the HEIs field, attributes of sustainability for QOL must incorporate the campus-wide dimensions with spatial attributes and not just some units. Also, each attribute must contain a significant and distinct component of the QOL construct. Furthermore, campus sustainability attributes should resonate with the more significant percentage of the HEIs stakeholders, practically neutral, and impact QOL construct. Lastly, an appropriate attribute should ensure the appraisal process via the combination of subjective and objective characteristics, as mentioned in **Section 1.3.1** above.

On the other hand, measurable unit indicators and sub-indicators that allow for quantification, appraisal, and communication of campus-wide sustainability challenges are required for effective operationalization and contextualization of quality lifestyle and sustainable campus. Essential sustainability, livability, and QOL challenges and trends within specific HEIs campuses are mostly measured using campus sustainability indicators and sub-indicators. Useful indicators and indicators for the appraisal of sustainability for QOL practices within HEIs neighborhoods should denote both the campus-wide component that would be appraised as well as those that can be appraised (i.e., indicate both idealism and feasibility). Consequently, this pragmatism and idealism in selecting effective and efficient sub-indicators and indicators make the process a challenging mission. The study scope and objectives are another basis for sub-indicators and indicators selection, as such, differences in the level of the selected indicator of importance and weights.

Therefore, the selection process of sub-indicators and indicators for campuses of HEIs in Nigeria will be based on the local context criteria, study scope, and objectives. Despite this study's limitation to the Nigeria geographical context, extant studies reveal the need to consider some basic standards during the indicators selection process (Al-Qawasmi, 2020). The SMART approach was adopted to ensure these fundamentals' considerations and ascertain the usefulness of the appraisal outcomes for campus/urban sustainability policy. The SMART approach was adopted to ensure that the selected indicators are (i) **specific** (reflect the uniqueness, need, and demands of the study area to allow for comparisons, (ii) **measurable** (guarantee sound and logical spatial analysis/measurement, empirical analysis, and well-founded methodology, (iii) **achievable** (ascertain trends, direction, and completion), (iv) **relevant** (certify its importance and appropriateness to sustainability for QOL within the scope of campus neighborhood), (v) **time-bound** (ensures predictability, comparison across time and at regular/annual basis).

1.4 Research Aim and Objectives

The proposed research aims to develop a campus-wide, spatial-based, and environmental-dimension sustainability indicators framework for the appraisal and visualization of sustainability performance within the campuses of HEIs in Nigerian. The goal is to set up performance-based spatial indicators to appraise campus-wide sustainability for QOL and visualize the outcomes via spatial technology. Visualizing the appraisal outcomes via spatial technology requires defining appropriate campus sustainability categories and indicators as well as a framework connecting them. Specifically, the research objectives are as follows:

1. To identify the campus-wide environmental sustainability categories that reflect and match the nature of Nigeria HEIs campuses.
2. To identify spatial-based indicators appropriate to appraise the identified campus-wide environmental sustainability categories.
3. To establish a practical measurement mechanism to appraise each sustainability category and spatial-based indicator.
4. To determine and verify the relative importance of each category and indicator and assign them the appropriate weight.
5. To propose a framework representing the linkage among the attributes (categories and indicators) in the form of a spatial data infrastructure model based on the Nigeria campus setting sustainability challenges.
6. To test the proposed model within the context of spatial strategy in a selected campus in Nigeria.

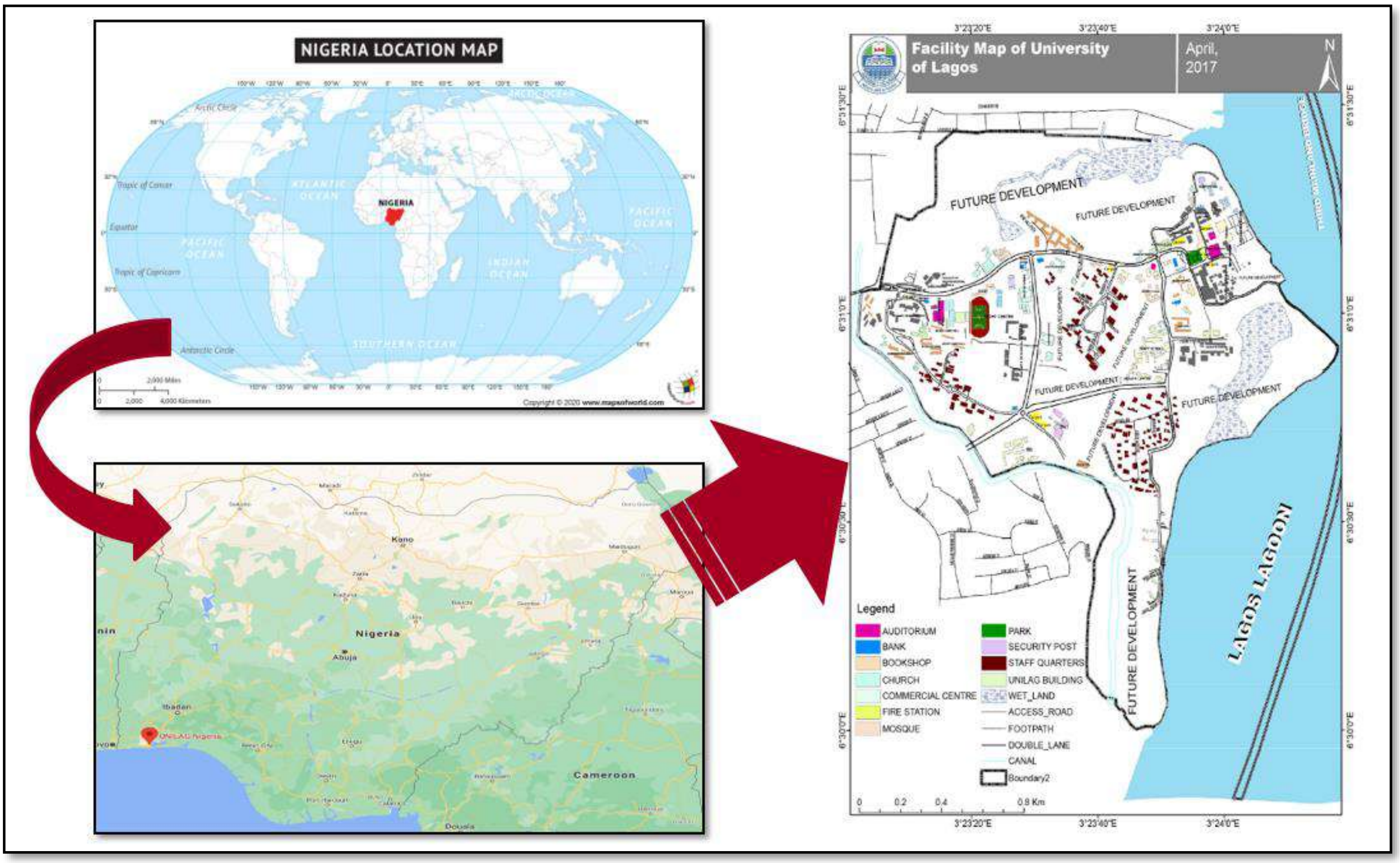
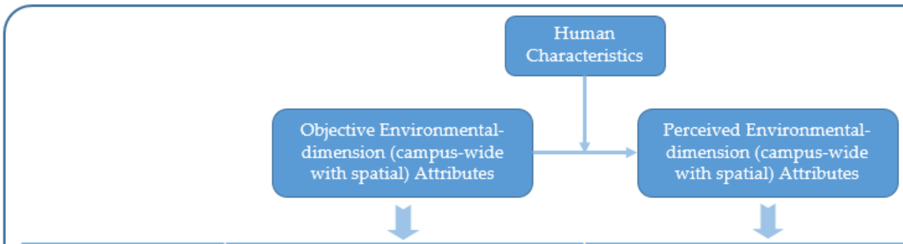


Figure 1. 2: Map showing the scope of the study limited to the University of Lagos

1.5 Research Methodology and Rationale

The sustainability for QOL multi-dimensional, multi-disciplinary, complexity, subjective and objective attributes, and research aim and objectives were discussed in the above sections. This section presents the adoption of multiple perspectives research approaches and methodologies utilized in this study. This study's research approaches and methodology is a paradigm shift from extant studies on CSA. The adoption of these approaches minimizes the limitations/weaknesses of utilizing only a few or selected perspectives which justifies the need for a combination of multiple methods (Johansson, 2002; Zapf, 2002). In **Figure 1.3**, the framework of the study's multi-perspective methods for exploring and operationalizing campus-wide environmental-dimension in campuses of HEIs in Nigeria was illustrated. The various approaches and methods were thereafter utilized in achieving the study’s aim and objectives. This thesis's subsequent chapters contain the detailed process and actualization of the proposed approaches and methods.



Research Scope	Campus Neighborhood	HEIs Stakeholders	Campus Neighborhood + HEIs Stakeholders
Appraisal Types	Objective/Quantitative (Type A)	Subjective/Qualitative (Type C)	Type B
Data Types	Secondary	Primary	Both
Data Sources	(i) Extant CSA Tools Documents (ii) Webpages of HEIs and Government Agencies (iii) Articles, Books, Conference Papers etc., (iv) Spatial Data: Vector, Raster etc.	(i) HEIs Social Media Platforms (ii) Town Planning Professionals	Mixed Method
Information Processing Strategies	Top-down	Bottom-up	Combined Strategy
Data Analysis	(i) Documents & Webpage Content Analysis (ii) Coverage Analysis (iii) SMART Analysis (iv) GIS-based Analysis	(i) Sentiment Analysis (ii) AHP	Combined Analysis Approach

Figure 1. 3: Study's Multi-perspective Methods

1.5.1 Objective and Subjective Appraisal

In **Section 1.3.1** above, Type A, B, and C research typologies were discussed to establish the concept of a sense of place and the need to conduct sustainability appraisal for QOL in campuses of HEIs based on subjective and objective approaches. In this section, the discussion of both research approaches in this project is presented, and their utilization was effected in actualizing the study's objectives.

Extant studies and CSA tools reveal that sustainability and QOL are embedded with subjective and objective attributes (Adenle et al., 2020a). Hence, their appraisal should be based on both approaches (Al-Qawasmi, 2020). Sustainability appraisal based on an objective approach concentrates on the objective societal environment. On the other hand, the subjective perspective focuses on human's subjective experience of their objective environment.

For the objective approach, quantifiable sustainability indicators and sub-indicators are utilized to disclose human demands regardless of their opinions and subjective environmental experience. For example, the objective appraisal of life expectancy of residence within campus neighborhoods could be obtained from government statistics without considering the concerned human population's perceptions. These data types are mostly made available by different departments and ministries based on census or official government registrations. Whereas, considering the deficient incorporation of QOL, environmental impact from the experience and perception of HEIs stakeholders, it has become imperative to utilize indicators from a subjective approach in evaluating campus-wide sustainability performance for QOL (Adenle et al., 2021).

Subjective evaluation is essential because different individuals have different perceptions, making diverse opinions, decisions, and conclusions on campus-wide dimensions that influence their QOL. This variation in what impacts QOL in campus neighborhoods could be the result of individual differences and backgrounds. Although humans within similar backgrounds also have the potential of different perceptions.

Extant studies (Al-Qawasmi, 2019; Hagerty et al., 2001; McCrea et al., 2006) reveal a negative correlation between sustainability for QOL attributes with a subjective and objective appraisal. Therefore, studies were mostly conducted via the combined approach's utilization (McCrea et al., 2006). As depicted in **Figure 1.3**, there are differences in both subjective and objective sustainability appraisal types, thus affecting the negative correlation observed in the literature. When conducting sustainability appraisal for QOL and livability, it is imperative to ascertain the local level assessment context. In this study, the level of aggregation is at the neighborhood level of HEIs. As such, to effectively explore and operationalize campus-wide sustainability for QOL at the Nigerian campuses of HEIs context, the utilization of multi-perspective methods incorporating various spatial-dimension attributes with both objective and subjective appraisal is indispensable.

1.5.2 Social Media, Sentiment Analysis and Machine Learning

Media practitioners are currently utilizing different social media platforms to communicate with various stakeholders across different organizations (Williams et al., 2014) that include but are not limited to sustainability for QOL initiatives, ideas, and efforts. These various social media platforms allow these media practitioners to pass sustainability for QOL initiatives to their audiences in their comfort zones. This communication via social media platforms is essential since individuals carry out several environmental-related behaviors. These actions include using bikes on the campus cycling lane to ensure a green-friendly campus, easing staff and on-campus student movement, and recycling reusable materials. Because young people in this age are growing up to start using different social media platforms, they are more likely to come across sustainability and quality lifestyle information on different internet-based applications than from strangers on the street (Williams et al., 2014).

With or without internet-based surveys, passive data could be used for a sustainable campus behavior framework or model for stakeholders' preferences on sustainable campuses. Studies conducted by some scholars found that a vast volume of information distributed on several social media platforms could be accessed (Sun et al., 2018). Social media can be referred to as an agglomeration of applications on the internet that allow users to generate content in the form of comments, like and unlike the content and sharing of the content (Hasnat et al., 2019).

The advent of social media has provided an avenue for public relations officers in different organizations to disseminate information and communicate with the relevant stakeholders in an approach that the traditional media could not. Social media users see themselves as being better positioned to effect pragmatic suggestions and solutions than those without a social media platform to communicate with the public or those in the position of authority. Different institutions are now beginning to utilize more than one social media channel to stabilize relationships and work on their reputations with essential stakeholders (Hamid et al., 2017). Organizations that include HEIs are now actively using social media as a communication channel (Carpenter et al., 2016).

Currently, there is a high reliance on several leading social media channels by HEIs due to their efficient and low-cost approach toward proffering solutions to challenges like inadequate awareness and engagement (Horhota et al., 2014). HEIs and other institutions take part in sustainability for QOL initiatives to ensure the assets, capital, and operation requirements of the contemporary and subsequent time human beings in the absence of degrading the quality lifestyle of the ecological community landscape and setting that are responsible (Alshuwaikhat et al., 2016). Sharing sustainability for QOL and livability efforts, policies, plans, initiatives, and progress could be efficiently carried out by sustainability practitioners via social media platforms. It was reported that contents of information that are disseminated via social media platforms are more effective in changing the orientation of people when it comes to the aspect of sustainability behaviors, attitudes, preferences, and knowledge awareness and campaign programs that are carried out through another education medium (Marcell et al., 2004).

In Nigeria, the present HEIs campus planning and development trend are not in line with most of the original campus master plans, preferences, and awareness of HEIs stakeholders. Many campuses are deplorable. As such, it is paramount to promote campus planning and development for sustainability and QOL based on the public level of importance of some selected sustainability indicators in the national, state, and local government context. It is an impeccable topic to assess the actual HEIs stakeholders' preference toward sustainable campuses.

The concept of a sustainable campus for QOL, livability, green campus, green building on HEIs campus, and green sustainability provide a platform that ensures the utilization of vast amounts of data on various social media networks to assess the HEIs stakeholders' preference toward campus sustainability. Twitter provides an effective avenue for its users to discuss sustainable campus, QOL, and other related issues on its platform. With the advent of Twitter, there has been a continuous increase in social media data on sustainability, QOL, and livability. Presently, Twitter social media data provides different HEIs administrators and managers with various sustainability information on HEIs and motivates HEIs campus planning departments to implement plans based on public preference and awareness.

With various electronic devices and internet connections, the Nigerian public supplies vast data on diverse social media channels like Snapchat, WhatsApp, Instagram, Facebook, and Twitter. These social media data could portray the pattern of sustainability and livability behavior among HEIs students, teaching and non-teaching staff, including campus mode of transportation behaviors and their management culture on infrastructure, settings, and environment. In this study, Twitter was chosen as the source of our social media data. There are over 499 million committed handlers producing every day more than 499 UGC across the globe (Hasnat et al., 2019). Official Twitter users in Nigeria are 6 million active monthly users out of an estimate of about 22 million active social media users (Buhari & Ahmad, 2014). Unlike in 2014, where studies showed that 47 out of the 112 Nigeria universities have Twitter accounts, presently, there are over one hundred HEIs with official Twitter accounts in Nigeria. As such, the volume of data required for this research is guaranteed. Twitter contains much campus-related information because several HEIs have an official Twitter handle, and students and university administrators use the platform to communicate information and experiences. This HEIs administrator's information is in addition to tweet content for other stakeholders to react to by replying with comments, retweeting, liking, and sharing the information with other stakeholders or interested parties.

Besides, the Application Programming Interface (API) of Twitter is opened to any social media researchers interested in accessing the platform database after Twitter administrators must have granted their requests from their headquarters. The data from Twitter obtained via mining provides a countless variety of information from every tweet for the analysis of sentiment using different open-source programming languages.

1.5.3 Top-down and Bottom-up Strategies

Comprehensive reviews of extant studies and CSA tools show that sustainability, livability, and QOL attributes are primarily gathered and compiled via two strategies: (i) top-down and (ii) bottom-up. The top-down approach strategy utilizes selected experts to arrive at QOL, livability, sustainability indicators, and sub-indicators. However, this approach lacks all relevant stakeholders of perceptions, views, and personal experience during the selection process. Contrarily, the bottom-up strategy considers the opinions of virtually all HEIs stakeholders in the process of arriving at the preferred attributes and their corresponding indicators. With the incorporation of the campus dwellers' attributes reflecting their demands and level of importance, valuable and beneficial communication concerning QOL and sustainability performance between the authorities and all stakeholders can be reached. Therefore, unlike most extant frameworks that formulated attributes and indicators using only the top-down approach, this study utilized a combined strategy. This strategy led to identifying and selecting campus-wide attributes and indicators with spatial-dimension that reflect and match campus nature within Nigeria's HEIs context.

1.5.4 Coverage Analysis

The coverage analysis is a structured approach that benchmarks the selected CSA tools to advance the stages of developing and selecting environmental-dimensions attributes (indicators and sub-indicators) for utilization/adoption with specific local/regional/national contexts. This structured approach was adopted by Al-Qawasmi, (2019) to select QOL indicators for a city in the Kingdom of Saudi Arabia. Extant literature also reveals factors (such as the absence of structure procedure in indicators selection) as reasons for indicators variations in existing sustainability appraisal tools. The rationale for its utilization in this research include but is not limited to (i) evaluating the level to which the selected extant tools covers the various criteria of environmental dimensions, (ii) understanding the structure of the analyzed extant tools, (iii) better comprehend the extensive amount of the included indicators and sub-indicators (iv) ensuring the selection of an appropriate, optimum and comprehensive list of indicators for the study's proposed framework. This study's findings also justify the importance of utilizing this technique for identifying and selecting environmental-based sustainability indicators.

1.5.5 Analytic Hierarchy Process

Attributes and indicators' preferences or level of importance and corresponding weights allocation are also fundamental sustainability components for QOL and livability studies. These preferences allocation is because sustainability is based on value judgments. An extensive review of the literature reveals that a vast amount of studies of weight allocation and attributes a level of importance are carried out using the subjective judgment of the principal researchers. This ad-hoc weighting scheme hinders the study's accuracy and trustworthiness and renders comparison with other appraisal challenges.

One of the approaches to allocating relative points for indicators selected for measuring sustainability performance in HEIs and developing an appraisal model is the weighting method. In this study, an initial review of the weighting methods utilized in existing CSA tools was carried out to enhance understanding of the challenges these methods could effectively resolve. The review was carried out to ensure (i) summarizing the existing documents related to the tools of appraising sustainability practices in HEIs, (ii) identification of the weighting methods utilized by these tools, and (iii) future utilization of the famous/adopted weighting method for CSA. Thirteen CSA tools documents were identified via desktop search and were critically reviewed to achieve the stated objectives.

The findings revealed that, unlike other approaches, the AHP method is (i) flexible/adaptable/adjustable, (ii) the large sample size is not required, (iii) an efficient level of consistency is achievable and can be efficiently utilized without the requirement of sophisticated equations and software. As such, its adoption for allocating weights, grades, scores, and level of importance to attributes of tracking sustainability activities in HEIs. The outcomes of the review also led to the proposal of the application of AHP for CSA.

1.5.6 Spatial Data and GIS-based Analysis

In this study, the usage of campus-wide, environmental and spatial-based indicator framework in Nigeria's case ensures that an accurate and spatially referenced data set that will act as a fact-based establishment for the decisions that are required to be carried out to achieve a sustainable campus enhancing the quality lifestyle for both present and future generations. As Nigeria moves forward with ensuring to create a more sustainable regional development across all regions where the current generation can meet their needs without compromising the ability of the future generations to do the same, the swiftly expanding HEIs campuses across the country are becoming the center of attention due to an increase in demand for staff and students, energy, waste generation, housing, etc.

Given the national increase in the number of universities and colleges in Nigeria between 1990 to 2020, many considered HEIs campuses the epicenter of several challenges. Despite these challenges, campuses provide a better life and economic chances for many stakeholders. Herein lies the opportunity to look at campuses afresh and shift the focus of their development and assessment to a spatial-based model.

In Nigeria and other developing countries, access to data is challenging, thus undermining sustainability appraisal for QOL and livability. After reviewing the literature, it became apparent that decision-makers had no use of spatial-based technology to assess campus-wide sustainability and create a more sustainable campus policy based on those assessments. However, the GIS-based approach can play a vital role in measuring environmental sustainability indicators and spatial dimensional appraisal. A campus-wide and spatial-based integrated framework can be primarily used to assess campus operations and management as this dimension of sustainability consists of spatially related indicators. In this study, a spatial software database was developed for the spatial sustainability indicators, after which environmental-dimension sustainability assessment of a selected campus was conducted. When remote sensing images are incorporated into the modeling software database, it facilitates data extraction from satellite sources. After that, these spatial data were used to measure some prioritized spatially-related sustainability indicators in a selected HEI campus in Nigeria.

1.5.7 Research Objectives and Methods for Achieving Them

Despite the study's multi-perspective methodology illustrated in **Figure 1.3** above, **Table 1.1** below reveals the research objectives and the methods utilized for achieving them. Other methods such as Questionnaire Survey, Georeferencing & digitization, Qualitative ranking, Quantitative data analysis (tabulation, descriptive statistics, i.e., percentages and averages), Institutional framework, Correlation analysis across the indicators, Reliability Analysis, Python Language were also conducted. However, they mainly were not reported or with detailed explanation in this thesis. This absence of a detailed explanation is because some of their outcomes give negative contributions to the study outcomes or were utilized during a pilot study.

Table 1. 1: Research Objectives and Methods for Achieving Them

Research objectives	Research Methods						
	Systematic Literature Review	Structured Coverage Analysis	SMART Approach	Content Analysis	Social Media UGC Analysis	Expert Survey (AHP)	GIS-based Spatial Analysis
To identify the campus-wide environmental sustainability categories that reflect and match the nature of Nigeria HEIs campus	√	√		√	√		
To identify spatial-based indicators appropriate to appraise the identified campus-wide environmental sustainability categories	√	√		√	√		
To establish a practical measurement mechanism to appraise each sustainability category and spatial-based indicator			√				
To determine and verify the relative importance of each category and indicator and assign them the appropriate weight						√	

To propose a framework that represents the linkage among the attributes (categories & indicators)	√	√	√	√	√	√	√
To test the proposed model within the context of national spatial strategy in a selected campus in Nigeria				√	√		√

The rationale for utilizing the selected research instrument and techniques for achieving the research objectives are explained in detail in each chapter where each of the selected techniques was utilized.

1.6 Thesis Organization and Overall Research Framework

The thesis is organized into eight chapters. Chapter one is the introductory chapter of the thesis. In Chapter One, the research background relating to sustainability for QOL and livability within the physical and spatial settings of HEIs was extensively discussed. Also discussed were the problem statements and research motivation based on the concept of sense of place and the research gap regarding environmental-dimension indicators coverage and the absence of a campus-wide sustainability appraisal tool in Nigeria HEIs. Besides, knowledge gaps relating to (i) social media usage, (ii) theoretical basis utilization, and (iii) weighting methods utilization were also identified. Furthermore, the (i) research aim and objectives, (ii) thesis research methods, and (iii) thesis research framework were discussed in Chapter One.

Chapters 2, 3, 4, and 5 explored the identified knowledge gaps in the existing CSA tools to ensure that appropriate answers are provided to the study's research questions before commencing with establishing an appraisal model in the project case study. In Chapter 2, a comprehensive exploration of the coverage of the environmental-dimension indicators was discussed. The content, coverage, and

SMART analysis outcomes led to the establishment of the environmental, campus-wide, and spatial-based indicators (ECS) Broad List, serving as the benchmark for actualizing the study's objectives one and two. Based on the variation in the use of environmental-dimension indicators with spatial attributes and the absence of spatial technology in appraising the campus-wide sustainability for a quality lifestyle in the extant tools, a framework for integrating spatial technology into CSA was proposed.

In Chapter 3, social media platforms and UGC usage in the extant CSA tools were explored. The comprehensive review, content, and coverage analysis reveal social media platform utilization in only three tools from the existing tools. This minor social media platform consideration is despite the development of most extant CSA tools in places with social media prevalent. One contains campus sustainability attributes and indicators with an environmental dimension from the three CSA tools with social media consideration. A web page content analysis of the social media platform embedded CSA tools reveals a lag in this tool's usage in sub-Saharan Africa countries. In addressing this gap, a framework integrating social media UGC into environmental CSA was proposed. Based on the strength and weaknesses of the latest information and communication technology, (i) Twitter social media platform, (ii) Python Programming language, and (iii) Azure Machine Learning for sentiment analysis was adopted.

In Chapter 4, a comprehensive literature review of the extant CSA tools was explored based on theoretical basis utilization. The chapter presented a background on the need to adopt a theoretical basis/framework for CSA establishment and evaluation and revealed an absence of a theoretical approach based on social theories. As such, five main social theories, which are (i) Marxism, (ii) functionalism, (iii) Anthropocene, (iv) symbolic interactionism, and (v) interactionist theories, were reviewed and compared. The theory of symbolic interactionism was adopted as the theoretical basis for the proposed framework and for the appraisal of campuses of HEIs in Nigeria based on the theory's tenets of incorporating social media UGC and the need for continuous monitoring and review. A theoretical framework integrating symbolic interactionism into CSA was developed. The symbolic interactionism framework being the theoretical/philosophical basis of this study, was thoroughly utilized in this study.

In Chapter 5, the study's objectives 1, 2, 3, and 4 were achieved. Unlike the previous chapters that only discussed comprehensive literature review, framework development, and pilot study, Chapter 5 presents outcomes based on social media UGC of Twitter accounts of HEIs across Nigeria. The validation and the establishment of the identified campus sustainability indicators' level of importance and weight are also based on expert consultation across Nigeria. Also, in this chapter, weighting methods in the extant CSA tools were comprehensively reviewed, and the appropriate multi-criteria decision-making technique was adopted for this study. QOL/livability advancement and the implementation of the sustainable campus and spatial technology tools and software in the African HEIs were also discussed in this chapter.

In Chapter 6, the overall framework of a modifiable campus-wide appraisal model (MOCAM) for sustainability in HEIs in Nigeria was presented. Chapter 6 is more or less an abridged version of Chapters 2, 3, 4, and 5. This outcome led to the actualization of the study's objectives 4 and 5. As such, in Chapter 7, the implementation, test-running, and validation of the overall framework were presented. In addition to social media UGC analysis and webpage content analysis of sustainability within the selected university; institution framework, spatial strategy sustainability analysis of the campus was carried out to allow for visualization of the selected spatial-based sustainability indicators. The spatial planning framework for Nigerian universities is not digital nor online. Extant laws compel all Nigerian universities to produce master plans before they can commence operations. All HEIs have plans and do implement them, though with varying levels of success. A digital universe is not conclusive; hence the caveat that this study does not utilize information from the study area master plan. Hence, the results that emanate from the analysis are likely to be skewed.

Finally, Chapter 8 (the conclusion of the thesis) presents the research outcomes summary. The practical, social and theoretical implication of the study was also discussed. This concluding chapter also discusses the value of the study to Nigeria, the study's limitation, policy recommendation, and direction for future research. Illustrated in **Figure 1.4** is the Thesis Organization and Overall Research Framework.

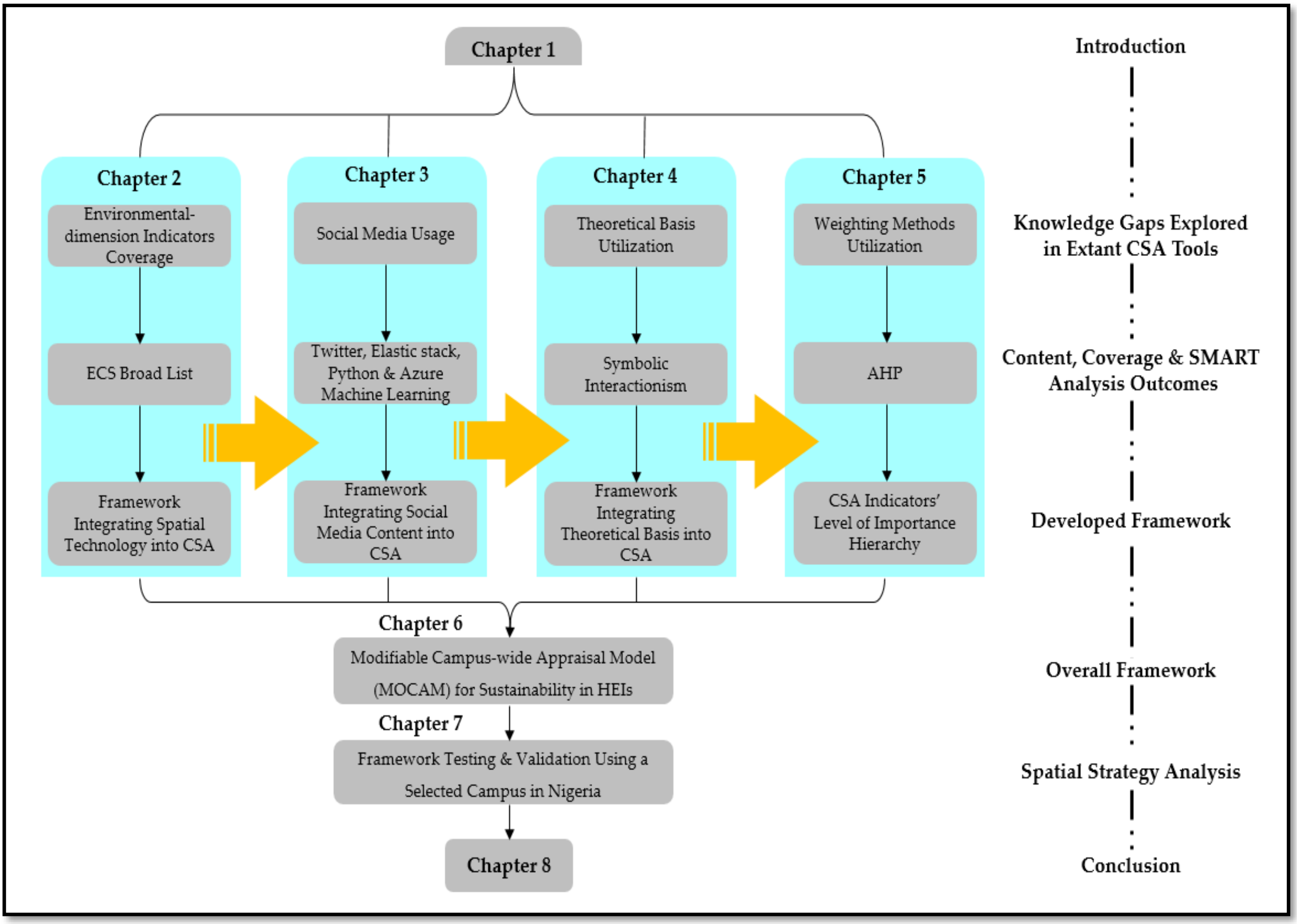


Figure 1. 4: Overall Research Framework

1.7 Chapter Summary

This chapter's content is the Introduction of a research project to contextualize the concept of sustainable campus for QOL via campus-wide environmental sustainability indicators and establishing an appraisal framework for Nigeria HEIs. Incorporating this nature of the QOL concept within the campus setting in a sub-Saharan African nation like Nigeria is a daunting endeavor. These challenges are due to identifying sustainability attributes and indicators that reflect the country's uniqueness and demands rather than studies in the literature with global perspectives or other geographical regions.

Based on a comprehensive literature review, it was observed that a consensus QOL and sustainability definition is absent. The variation in sustainability and QOL research techniques, definitions, and interpretations reveal the complexity and multi-disciplinary nature of the concept rather than its limitations. Most importantly, the diversity shows the relevance of different HEIs campus (place) unique characteristics within their local context. As such, the basis of sustainability for QOL and livability-related studies is their operationalization establishment to allow for HEIs campus appraisal.

In ensuring the appraisal of HEIs campus sustainability for QOL in the study area and retrieve essential data reflecting local dimensions and interpretations, the following multi-perspective approaches were proposed: (i) combined secondary and primary data type (ii) data sources from existing CSA tools documents, webpages of HEIs and government agencies, and HEIs social media platforms (iii) top-down and bottom-up integrated approaches, and (iv) objective (Type A) and subjective (Type C) appraisal approach.

This chapter also includes the relevance of identifying relevant attributes and indicators to monitor and appraise HEIs sustainability performance. The proposed framework reveals that it is paramount to operationalize individual indicators via the SMART approach during the attributes and indicator selection. This approach will ensure accurate measurement and appraisal of the selected campus-wide spatial indicators and result visualization using the selected spatial analysis tool. The SMART approach will also ensure that the selected indicators are relevant and specific for utilization within the campuses of HEIs in Nigeria to allow for data comparison. The relevance of social media and spatial technology is also discussed. Likewise, the research objectives and framework, as well as the thesis structure, are presented in this chapter.

CHAPTER 2: TOWARDS THE DEVELOPMENT OF A FRAMEWORK FOR INTEGRATING SPATIAL SOFTWARE INTO ENVIRONMENTAL CSA[2]

2.1 Chapter Overview

The introductory chapter presented the background to knowledge, research motivations, aim and objectives, and the study's scope. This chapter presents the initial attempt towards the development of a CSA framework for HEIs in Nigeria. To actualize the study's first and second objectives (i.e., identify the campus sustainability categories and their corresponding indicators that reflect and match the nature of Nigeria HEIs campuses), this chapter explores the coverage of environmental dimension indicators in some selected CSA tools.

2.2 Introduction

The knowledge base around the world is expanding at an incredible pace. One such sector that has undergone a rapid transformation during the last few decades is developing information-based systems. These systems have made it easier for professionals in the built environment to successfully and efficiently complete humongous urban and campus planning tasks within a short duration. The information systems that derive their roots from geography have certainly made more infiltration due to the increased awareness among policymakers and decision-makers to rely on these systems for public policy formulation. One such system is the geographic information system (GIS).

GIS allows incorporating, manipulating, and displaying massive datasets, making it more adaptable than any other spatial application to guide decision-making. GIS, a computer-based system, can process data from various sources and integrate them with geographical location while providing the user with the information necessary for making informed decisions (Han & Kim, 1989). The compilation,

[2] This chapter is partially published in:
Adenle, Yusuf A., Chan, E. H. W., Sun, Y., & Chau, C. K. (2020). Exploring the Coverage of Environmental-dimension Indicators in Existing Campus Sustainability Appraisal Tools. *Environmental and Sustainability Indicators*, *8*(August), 1–11. https://doi.org/10.1016/j.indic.2020.10005

stockpiling, dissection, and presentation of the combination of topographical, ecological, and non-ecological data for specialized activities could be carried out on the GIS platform (de Winnaar et al., 2007). Given that framework development is an essential component of urban and campus planning design and strategic sustainability development, GIS and other related spatial tools could be utilized to establish CSA embedded with spatial-based indicators, after which the data needed as input during and after the appraisal process could be generated. Using GIS as a tool for the CSA project could help determine a set of scenarios that ultimately reflect the situation of the overall campus-wide sustainability for the QOL situation. Where data about spatial components of campus development and appraisal project are missing, a GIS-based integrated framework could help determine the value of the missing data by extracting the values from satellite images and maps that can be freely obtained online and geo-referenced on the GIS map.

In urban and campus planning, GIS provides a comprehensive digital database for project boundary areas to improve socioeconomic, environmental, and developmental coordination. A GIS-based CSA project could also help analyze existing data to generate more information about a selected HEIs campus. For instance, in a GIS-based urban planning project, GIS can allow more comfortable priority settings for conserving natural land features when linked with their unique locational attributes (Geneletti, 2004). GIS also helps measure and calculate the percentage of urban roads with bus lanes, walkways, and bicycle lanes. Also, the accessibility and compactness of urban center facilities can be analyzed using GIS techniques (buffering or network analyses). The result can be input into the overall assessment of the urban center. During the implementation of a GIS-based urban planning project, GIS also allows the production of a geographic area chart required for progress monitoring, unnecessary spending, and the review process in campus planning and development projects.

However, various sets of tools have been devised by different organizations to appraise academic campuses' sustainability practices and performance. These assessment tools range from the rating system to a ranking system and differ in assessment scope (Sonetti et al., 2016). Multiple systems for

CSA are in operation across the globe. Sustainability appraisal is a complicated evaluation method that does not only encompasses the socio-economic and environmental aspects of sustainability. Instead, it extends to the community's cultural elements the appraisal is being conducted (Sala et al., 2015). Devuyst (2001, p.9) defines a system of sustainability appraisal as a tool that assists "*decision-makers and policy-makers decide what actions they should take and should not take in an attempt to make society more sustainable.*" However, within the HEIs campus situation, the purpose of CSA systems varies from (i) providing an overall picture of the status of sustainability within HEIs campuses, (ii) encouraging the reporting, benchmarking, measuring, and comparison of sustainability achievements and efforts of various HEIs (iii) providing a clear understanding of the progress that is being made by HEIs stakeholders towards sustainability (iv) creating a mechanism for exchange of experiences and motivations between HEIs and (v) identifying the HEIs campuses strength and weaknesses and the introduction of activities of education for sustainable development (Alghamdi et al., 2017). Others include but are not limited to assisting in implementing HEIs sustainability plans and greening HEIs campuses.

Also, there are various scope, focus, weighting methods, functions, flexibility, state of development, and access to information for different CSA frameworks (Kamal & Asmuss, 2013; Shriberg, 2002a). These variations, complexity, and comprehensiveness also increase based on several assessment criteria and indicators in addition to the enormous amount of data set for both collection and analysis. CSA has become one of the most significant undertakings engaged by most HEIs, educational stakeholders, private and government organizations worldwide in the past few decades. Besides, several CSA tools have been established across the globe to assess, track, measure, and evaluate the level of sustainability in HEIs campuses (Alghamdi et al., 2017; Alonso-Almeida et al., 2015; Alshuwaikhat & Abubakar, 2008).

The continuous increase in the utilization of different CSA tools by several HEIs across the globe to track sustainability performance within their campuses meant that their indicators for appraisal purposes in campus sustainability are significant to academic administrators, researchers, practitioners, stakeholders, and policymakers. A list of selected indicators with some guidelines is the significant component of the various existing CSA framework to ensure an objective presentation of the appraised campuses' sustainability status. But a comprehensive review of the literature reveals the absence of studies specifically for exploring spatial, campus-wide, and environmental-dimension indicators of HEIs campuses in existing CSA tools despite the massive geographical area with several infrastructure and functions of most HEIs campuses. HEIs campuses are also home to complex operations and multiple activities with severe impacts on the environment. Several studies have also been conducted stating the need to incorporate the spatial dimension of sustainability into sustainability appraisal (Alshuwaikhat & Aina, 2006; Stylianidis, 2012).

Indeed, the dimension of spatial-based indicators is paramount for an efficient appraisal of sustainable development's environmental aspect. There is an urgency to incorporate the sustainability indicators with spatial dimension and their analysis based on GIS techniques to conduct sustainability appraisals in diverse communities like HEIs campuses. For instance, a spatial decision support system (SDSS) has been reported to modify spatial-based data into its system to improve decision-makers' accuracy on spatially referenced information. Therefore, indicating the importance of the SDSS and computer-based framework (Maniezzo & Mendes, 1998). While the reasons for the variation in the list of indicators in existing CSA have not been extensively studied, examining the campus-wide, environmental, and spatial-based indicators coverage practices in existing CSA tools is lagging in extant literature. This chapter aims to explore the inclusion and utilization of campus-wide, environmental and spatial-based indicators in existing CSA tools and their capacity to appraise diverse aspects of sustainable campus via the utilization of a structure coverage evaluation approach. The SMART approach was also utilized to analyze the extracted spatial-based indicators from the tools to identify indicators adopted for GIS and related software CSA frameworks.

2.3 Campus Sustainability Indicators, Categories, and Appraisal Tools

As mentioned above, one of the aims of this chapter is to explore the variation in the utilization and incorporation of environmental-based indicators (with campus-wide and spatial-dimension) and their categorization in the existing CSA. However, this section of the chapter discusses the composition and the arrangement of CSA tools and their capacity in appraising sustainable indicators and sub-indicators relating to HEIs.

2.3.1 Appraising Sustainability in HEIs Campuses: Categories, Indicators, and Sub-indicators

A review of the literature indicated that the dominant tools for CSA, whose spatial-based indicators are the focus of this study, are the Global Reporting Initiative (GRI) and STARS. The GRI is a voluntary standard-setting tool used for sustainability appraisal and reporting, mainly in the corporate world (Hahn & Kühnen, 2013; Kolk, 2010). Some HEIs also utilize it in assessing their campus sustainability performance. The GRI is a global triple bottom line and multi-stakeholder framework. On the other hand, STARS provides sustainability appraisal guidelines and a framework to assist HEIs in assessing and measuring their sustainable campus performance progress. Indeed, the efficacy of any approach to appraising campus sustainability performance progress can only be determined if we have some yardstick or a set of criteria. In the absence of such a criterion, the report's success in attaining campus sustainability is subject to different interpretations.

However, numerous sets of CSA indicators have been developed to the extent that selecting suitable ones is a huge but essential task. That is why some frameworks of indicators selected to suit particular objectives, settings, and resources available are developed for CSA. The frameworks also aim to minimize CSA challenges like data limitations and the selected indicators' capacity to collect adequate and relevant information about the HEIs. For this purpose, the following two sub-sections analyze the concept of campus sustainability indicators and sub-indicators and their categorization. This categorization analysis is because all the existing CSA tools are comprised of sub-indicators and indicators grouped under categories/criteria in the form of hierarchies.

2.3.1.1 Campus Sustainability Appraisal Indicators and Sub-indicators

Three primary ways of appraising sustainability are found in extant literature (Dalal-Clayton and Bass, 2002). The first is an "*account of sustainability status*," followed by "*narrative assessment*," and lastly, an "*indicator-based assessment*," which is the focus of this chapter. Indicator-based sustainability appraisal utilizes indicators or lower subsets known as sub-indicators that are systematically selected to address urban or campus sustainability challenges. These selected sets of indicators and sub-indicators were mainly utilized within a specified period in which the current appraisal will be compared with the one conducted previously, ensuring that consistency is incorporated in the appraisal process. The sustainability appraisal approach based on a set of sustainability indicators mainly involves a comprehensive prioritization process and systematic organization of indicators and or sub-indicators. Compared with narrative assessment or an account of sustainability status, utilizing this approach ensures better strategy advancement, performance follow-up, and genuine decision-making. Most importantly, it describes HEIs' strengths and weaknesses. Also, their transparency and objectivity (Kumar et al., 2009) provide easy measurement with more outstanding performance than the other sustainability appraisal techniques.

2.3.1.2 Campus Sustainability Appraisal Categories

A principal definition of a sustainable university by Velazquez et al. (2006) states that a university is sustainable when the whole or part of the campus addresses, involves in or promotes locally or globally "*the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles*" (p. 812). To ascertain the rate at which HEIs campuses as a whole or in part addresses the minimization of its negative environmental impacts based on its functions and operations, several CSA tools have been established in performing this task. Though, the literature review of extant articles shows that these tools and practices in appraising campus sustainability typically organize sustainability indicators under a classification system known as criteria (Alghamdi et al., 2017), dimension, or categories. The list of indicators and or sub-indicators are represented within the categories theme. Therefore, every dimension or category contains a wide range but a distinct CSA aspect and sustainable quality lifestyles.

For example, New York University carried out its campus sustainability assessment using STARS along with the guidelines of eight categories. Similarly, the University of Calgary (UOC) developed an institutional sustainability plan utilizing the STARS assessment system categorization as a baseline. The primary rationale for this selection is the reliance of North American academic institutes to measure their sustainability performance. However, UOC and several other North American universities have made necessary modifications to STARS categorization to encompass the indigenous needs for their sustainability plans and appraisal framework.

2.3.2 Selection of Categories, Indicators, and Sub-indicators

A review of extant literature shows a myriad of appraisal tools consisting of several single-attribute appraisal tools and various multi-criteria appraisal tools. Although the focus of this chapter is on tools with multi-criteria yet the majority of them have the conventional three fundamental components, which are (i) the local/regional/national context, (ii) the weighting scheme, and (iii) criteria or domain. Although, these components of the multi-criteria assessment tools vary from moderately to significantly from one tool to another. The variation in the major components of various assessment systems are explained as follows:

The first (*i.e., local/regional/national context*) contains attributes, features, and characteristics of every country's HEIs in terms of different socio-economic and environmental elements across the globe. These differences play a huge factor in determining the individual assessment system's indicator components in different countries worldwide. According to Banani et al. (2013), examples of these local attributes that vary from one region to another include but are not limited to (i) climatic conditions, (ii) geographical composition, (iii) government laws and policies, (iv) natural resources utilization (v) knowledge of the building compositions (vi) knowledge of the relevant historical elements, and (vii) public awareness and cultural value. This variation has led to the challenges of utilizing a CSA system that works in one country for another country (Alyami & Rezgui, 2012). Besides, this has also led to establishing different assessment criteria for different assessment ratings and appraisal systems.

The second (*i.e., Weighting Scheme*) entails allocating importance or preferences quantifiable between a set of indicators (Tanguay et al., 2010). Many scholars have critiqued this value allocation method because of the inconsistency associated with the process and the absence of the objectivity of the allotted weight to the individual indicators (Tanguay et al., 2010). Although, some scholars opined that indicators assessment utilizing this approach considers the involvement of citizens and relevant stakeholders. The last is an assessment criterion. However, for a campus sustainability assessment framework to achieve a comprehensive appraisal of HEIs campus, it is agreed upon by several experts that it must combine both qualitative and quantitative criteria. Despite the above justification for the variation in the inclusion, selection, and adoption of indicators amongst the existing CSA tools, another primary explanation is the absence of "*systemic standard procedure*" that accompany the identification of indicators that reflect the objectives of a specific study or match the nature of the case study (Diener, 1995). The inclusion of the absence of GIS and related spatial tools should also be included. The following section discusses the adopted methodology of this chapter to incorporate a standard systemic procedure. While this chapter extensively discussed the CSA criteria/domain, subsequent chapters discussed weighting schemes and contextualization into a local context in detail.

2.4 Methodology

This chapter's main objective is to comprehensively explore selected existing appraisal tools for sustainability in HEIs campuses. This comprehensive exploration was undertaken to spot inclusion and variations in environmental-dimension utilization (encompassing the campus-wide and spatial-based) indicators, sub-indicators, and their broad theme categorization. A comprehensive list that focuses only on campus-wide, environmental and spatial-based indicators was derived from 13 current CSA tools in actualizing this objective. The comprehensive list named 'ECS (Environmental, Campus-wide and Spatial-based indicators) Broad List' (see **Table 2.2**) was extracted to create a template for relative analysis across sustainability appraisal practices in HEIs. As such, the ECS Broad List serves as this chapter, subsequent chapters, and the overall study's foundation for exploring the spatial-based indicators in every selected CSA tool. The benchmarking of the indicators to the ECS Broad List will allow for a detailed analysis of each tool's hierarchical categorization of indicators. It will also set the basis for selecting the indicators with the local/national context of this research.

Knowing that CSA tools are deemed as strategies for operationalizing sustainability within the campuses of HEIs, it is, therefore, paramount to adopt an appropriate approach for exploring and analyzing the sustainable indicators affecting them. The adoption of this approach is due to the presence of several sustainability indicators, rendering the selection process for CSA a severe challenge. The SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) approach (Alshuwaikhat et al., 2017; Shahin & Mahbod, 2007), depicted in **Figure 2.1**, guarantees efficiency and productive spatial-based attributes were used to analyze the ECS Broad List. The SMART approach also ensures that all required considerations before selecting spatial-based indicators for the CSA model incorporating GIS or other related spatial techniques or tools are met.

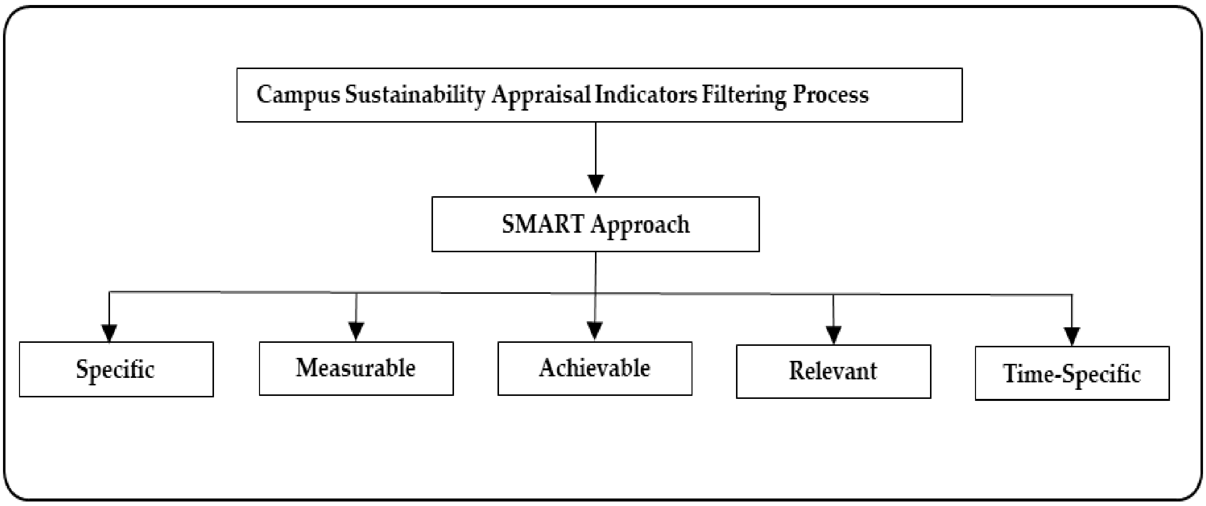


Figure 2. 1: SMART Approach

2.4.1 Existing CSA Tools

In this study, 13 CSA tools were chosen for structured coverage analysis. The 13 existing CSA was selected for the following reasons: Firstly, they are all available in English and not in other languages like German and French. During this study, a tool written in German was excluded from the selected tools. Secondly, they are indicator-based appraisal tools. CSA tools that are either narrative-based (such as the tools developed by the World Bank, UN-Habitat, or World Health Organization) or those in the form of an account of sustainability status were all excluded. Thirdly, they are developed to be used explicitly for the appraisal of campuses within HEIs. Tools such as GRI, a voluntary standard-setting tool utilized for sustainability appraisal and reporting mainly in the corporate world, were excluded. Lastly, all have either a technical manual, report, or publication for easy accessibility and reference. Tools such as Benchmarking Indicators Questions – Alternative University Appraisal (BIQ-AUA), Unit-based Sustainability Assessment Tool, and The Green Plan were excluded from the selected tools based on this.

2.4.2 ECS Broad List Selection Process

The ECS Broad List is an extensive list of environmental-dimension (that encompasses the campus-wide and spatial-based indicators, sub-indicators, and their broad theme categorization) extracted from the selected analyzed CSA tools. The arrival of the ECS Broad List follows through two stages. First, all categories of indicators from the 13 tools were extracted to arrive at 55 categories, 220 indicators, and 266 sub-indicators, as shown in **Table 2.1**. The second stage involves excluding all categories, indicators, and sub-indicators that are not within this research scope. Thus, the numbers extracted during the first stage were reduced to 13 categories, 50 indicators, and 65 sub-indicators at the end of the second stage, as shown in **Table 2.2**.

Table 2. 1: Overview of the 13 CSA Tools

Campus Sustainability Appraisal Framework	**Version Reviewed**	**Categories**	**Indicators**	**Sub-indicators**
Sustainability Assessment Questionnaire (SAQ) ULSF, (2009)	2001	7	-	-
Graphical Assessment of Sustainability in University (GASU) Lozano, (2006)	2006	4	8	59
Sustainable University Model (SUM) Velazquez et al., (2006)	2006	4	23	-
University Environmental Management System (UEMS) Alshuwaikhat & Abubakar, (2008)	2008	3	8	23
Assessment Instrument for Sustainability in Higher Education (AISHE 2.0) AISHE 2.0 Manual, (2009)	2009	5	30	-
Unit-based Sustainability Assessment Tool (USAT) Togo & Lotz-Sisitka, (2009)	2009	-	9	-
Three dimension University Ranking (TUR) Lukman et. al., (2010)	2009	3	15	-
DPSEEA-Sustainability index Model (D-SiM) Waheed et al., (2011)	2011	5	20	56
Graz Model for Integrative Development (Graz) Mader, (2013)	2012	5	15	-
Sustainable Campus Assessment System (SCAS) Hokkaido University, (2013)	2013	4	25	34
Adaptable Model for Assessing Sustainability in Higher Education (AMAS) Gomez et al., (2015)	2014	3	9	25

UI's GreenMetric University Sustainability Ranking (Green Metric) Universitas Indonesia, (2019)	2019	6	39	-
STARS STARS Technical Manual, (2019)	2019	6	19	69
Total		**55**	**220**	**266**

This reduction of the indicators from the first stage to only spatial-based indicators that fall under the environmental pillar of sustainability, operations, and with campus-wide planning and development of HEIs campuses ensures spatially referenced and definite data set for evidence base sustainability appraisal for both current and generation unborn are achieved. This reduction to only spatial-based indicators will eliminate the challenges of appraising sustainability in HEIs in the global south, which include the absence, inadequate or restrained access to essential information for campus sustainability appraisal project, selecting a set of indicators, and difficulties in indicators measurement. A comprehensive system that will help university environmental managers carry out campus sustainability assessments on a unified platform could be achieved with the integration of spatial-based indicators into the framework of GIS and other related spatial tools. The integration of GIS into indicator framework in sustainability assessment will better integrate space to sustainability indicators, thus allowing visualization of the assessment outcome. Also, GIS integration with the spatial-based indicator framework can compare assessment results over the years as previous data is stored in the GIS database.

Table 2. 2: ECS (Environmental, Campus-wide and Spatial-based indicators) Broad List

Tools	Categories	Indicators	Sub-indicators
SAQ	(1) Operations		

GASU	(2) Environmental	1. Environmental	(1) Materials (2) Energy (3) Water (4) Biodiversity (5) Emissions, effluents, and waste (6) Transport
SUM	(3) Sustainability on campus	(2) Energy Efficiency (3) Global Climate (4) Water efficiency (5) Composting (6) Transportation and commuting (7) Hazardous Waste Management (8) Non-Hazardous Waste Management (9) Environmental Procurement (10) Natural Heritage (11) Access for Handicapped People	
UEMS	(4) University EMS	(12) Environmental Management and Improvement	(7) Minimize negative impacts of operations (8) pollution prevention (9) Energy efficiency (10) Resources conservation (11) Environmental improvement (12) Waste reduction (13) Recycling
		(13) Green Campus	(14) Green buildings (15) Green transportation (16) Campus preservation
AISHE	(5) Operation	(14) Ecology (15) Physical structure	
USAT		(16) Operations and Management	
TUR	(6) Environmental		

D-SiM		(17) Environment	(17) Annual energy consumption rate
		(18) Environment	(18) Production of greenhouse gases (19) Production and consumption of ozone-depleting substances (20) Production of emission, effluents, and waste (21) Amount of energy used (22) Amount of water supplied and distributed/collected for purification (23) Increasing transport density
		(19) Environment	(24) Concentration of greenhouse gases (25) Concentration of emissions, effluents, and waste (26) Rate of depletion of energy resources (27) Rate of water consumption and quality (28) Percentage daily commute by motor vehicle and transport conflicts (29) Exceedance of noise level
		(20) Environment	(30) Changes in environmental conditions (31) Proportion of people exposed to poor air conditions (32) Proportion of people exposed to poor water quality (33) Proportion of people exposed to various hazards (34) Proportion of people exposed to high

			noise levels (35) Impact on energy resources
		(21) Environment	(36) Effects on human health (37) Effects on environment (38) Effects on biodiversity
Graz			
SCAS	(7) Environment	(22) Ecosystem	
		(23) Land	(39) Greenspace and forest land (40) Other open space
		(24) Public Space	
		(25) Landscape	
		(26) Waste	
		(27) Energy and resources	(41) Energy Management (42) Greenhouse gases (43) Renewable energy
		(28) Basic Equipment	
		(29) Facilities	(44) Environmental performance (45) Indoor environment
		(30) Transportation	(46) Flow planning (47) Pedestrians and cycling (48) Connecting with the local community

		(31) Use of historical assets on campus	
		(32) Disaster prevention locations	
AMAS		(33) Resource consumption	(49) Energy consumption (50) Energy efficiency measures (51) Water consumption (52) Water efficiency measures (53) Hazardous waste management
Green Metric	(8) Setting and infrastructure	(34) The ratio of open space area to the total area (35) Total area on campus covered in forest vegetation (36) Total area on campus covered in planted vegetation (37) Total area on campus for water absorption besides the forest and planted vegetation	
	(9) Energy and climate change	(38) Number of renewable energy sources in campus	
	(10) Waste	(39) Organic waste treatment (40) Inorganic waste treatment (41) Toxic waste treatment (42) Sewage disposal	
	(11) Water	(43) Treated water consumed	
	(12) Transportation	(44) Shuttle services	
STARS	(13) Operations	(44) Air & Climate	(54) Greenhouse Gas Emissions

		(46) Buildings	(55) Building Design and Construction (56) Building Operations and Maintenance
		(47) Energy	(57) Building Energy Efficiency (58) Clean and Renewable Energy
		(48) Transportation	(59) Campus Fleet (60) Commute Modal Split
		(49) Waste	(61) Waste Minimization and Diversion (62) Construction and Demolition Waste Diversion (63) Hazardous Waste Management
		(50) Water	(64) Water Use (65) Rainwater Management
Total	13	50	65

2.4.3 Structured Coverage Evaluation and SMART Approach

The ECS Broad List established in this study is utilized as a base case for carrying out a structured coverage evaluation that entails the cross-examination and exploration of the spatial-based categories, indicators, and sub-indicators in the 13 tools. The adopted evaluation approach was carried out to ascertain the indicators' coverage (directly or using the same operational definition) across the individual tool.

After that, the SMART approach was applied to ensure that the ECS Broad List is further analyzed to reduce the list to only the set of spatial-based indicators that can be effectively incorporated into a GIS and or related software framework. The SMART approach ensures that the selected indicators are 'Specific' to dismiss lack of clarity during the process of CSA; 'Measureable' to aid numerical quantification and statistical analysis; 'Achievable' to arrive at the aim and objectives of an appraisal process; 'Relevant' to the aim and objectives of an appraisal process, and lastly 'Time-bound' to give room for adaptive change and repetition of an appraisal.

2.5 Results and Analysis

2.5.1 General Description of the Analyzed CSA Tools

The versions of the CSA tools for structured coverage evaluation and SMART approach analysis are between 2001 and 2019 has displayed in **Table 2.1**. While most of the tools are developed to be utilized in every part of the world, some are designed for HEIs in regions such as North American, and others are country-specific. The indicators that fall under campus sustainability, such as curriculum, research & scholarship, economic, social, outreach & partnership, institutional commitment, etc., were not considered for analysis in this study. Indicators or sub-indicators that are included under broad categories such as operations and environmental-dimension without campus-wide or spatial-based operational definitions are also excluded from the final selection. The analysis only concentrates on indicators with spatial coverage of HEIs campuses.

The review of the technical manuals, reports, and articles of the 13 CSA tools show that none of the selected appraisal tools used social media data, main social theories nor GIS or spatial-based techniques for appraisal of a set of environmental indicators for CSA with a spatial dimension (i.e., they cannot be linked to a spatial or geographical region). Assessment of the existing tools based on a tested conceptual model shows that most of the tools are driven by the availability of indicator-based sustainability data and planning and developmental policies but not driven by a sound theoretical framework. Social theories such as interactionism, post-modernism, structural functionalism, and Anthropocene were missing in driving the analyzed tools' development. Some of the challenges of not utilizing or incorporating a tested theoretical basis are the difficulties of knowledge accumulation and inappropriate methodology usage. With the advent of different social media platforms since early 2000, one will expect the CSA tools to utilize enormous campus sustainability data on these media platforms to drive the design and selection of their indicators.

In the technical manual of STARS, GIS was referred to as HEIs coursework and not a tool for appraising spatial indicators. However, the presence of spatial dimension indicators in its framework can be observed in **Table 2.2**. It states: "*although specific tools or practices such as GIS (Geographical Information Systems) or engineering can be applied towards sustainability, such courses would not count unless they incorporated a unit on sustainability or a sustainability challenge, included a sustainability-focused activity, or incorporated sustainability issues throughout the course*" p.6 (STARS Technical Manual, 2019). However, it is imperative to provide guidelines about GIS because the study by Urbanski & Filho (2015) suggested that the level of adoption of explicitly stated issues in the guidelines is higher than the implicit issues. The absence of GIS and spatial software utilization in appraising indicators with spatial-dimension in all the tools shows this study's need.

2.6 Findings and Discussion

The unique CSA tool reviewed has different sets of spatial-based sustainability indicators and sub-indicators under various categories and diverse methodologies (i.e., multi-criteria decision methods) in adopting the arriving at the selected indicators. The presence of these variations in these tools is associated with some of their pros and cons. In this discussion section, the findings and results for these variations are presented.

2.6.1 Structured Coverage Evaluation

The structured coverage evaluation was performed on the 13 CSA tools to explore the degree of coverage with the ECS Broad List. This coverage's degree was carried out to ascertain the indicators' coverage (directly or using the same operational definition) across the individual tool. In this chapter, CSA tools with indicators or sub-indicators of 5 and above were referred to as 'deep coverage.' The depth of coverage evaluation reveals that five tools (SUM, D-SiM, SCAS, GreenMetric, and STARS) meet the attribute of deep coverage at the indicators hierarchy. On the other hand, six tools (GASU, UEMS, D-SiM, SCAS, AMAS, and STARS) met deep coverage characteristics at the sub-indicators hierarchy. Only D-SiM, SCAS, and STARS extensively included spatial-based indicators at both indicators and sub-indicators levels. The findings of other coverage evaluations are discussed in the following two sub-sections.

2.6.1.1 Number of Categories, Indicators, and Sub-indicators in a Tool

The findings reveal some variations in spatial-based campus sustainability indicators coverage practices in appraising the level of sustainability in HEIs. The number of categories varies from zero to five as tools such as USAT, Graz, and AMAS are without spatial-based sustainability categories, as shown in **Figure 2.2**. Despite the presence of 13 unique categories of spatial-based indicators and sub-indicators, only two categories (i.e., Operation* and Environment*) are used in more than one CSA tool. One of the outcomes that deserve attention is the average number of spatial-based categories (i.e., one) used in most tools. This outcome shows that the existing tools did not consider including spatial-based sustainability categories when designing their CSA tools. Five out of the six CSA categories in UI GreenMetric World University Ranking (managed by Universitas Indonesia) are campus-wide in dimension, indicating this tool's interest in addressing the study's focus. However, incorporating GIS or spatial-based techniques into its framework in appraising these dimensions is missing.

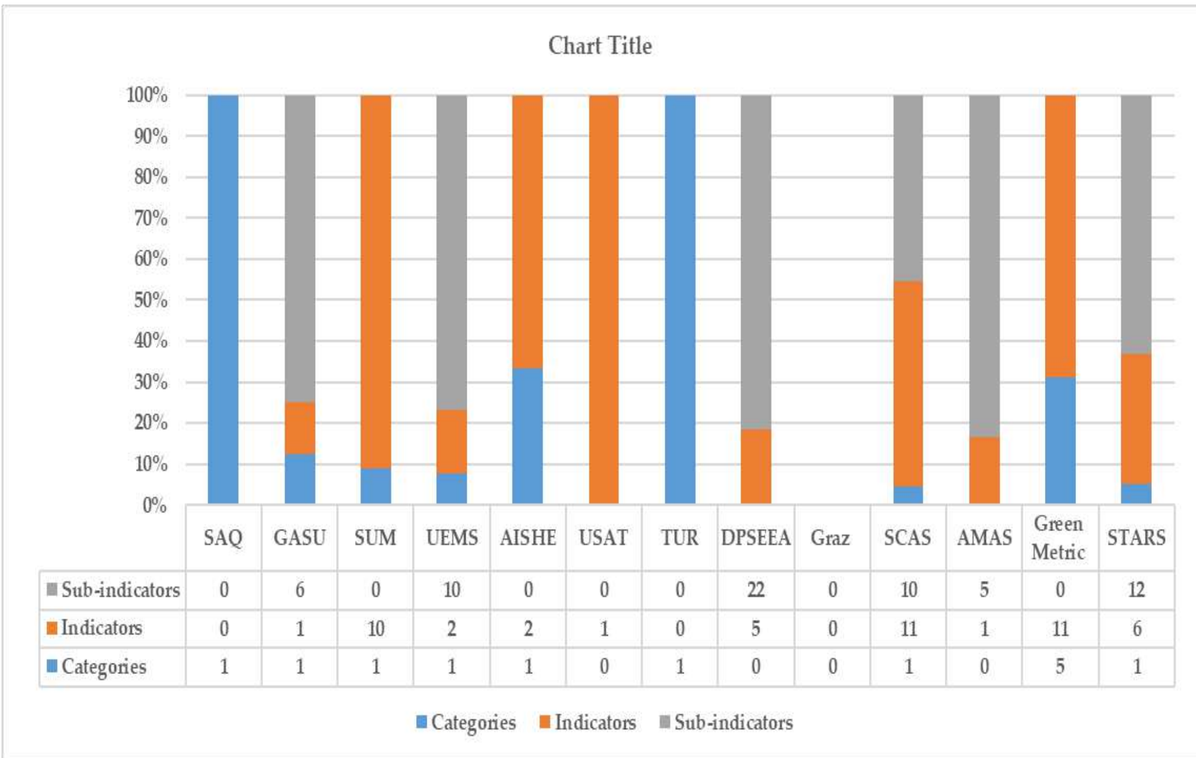


Figure 2. 2: Number of Spatial-based attributes from the 13 CSA Tools

Concerning the indicators and sub-indicators, the total number of unique indicators and sub-indicators is 50 and 65, respectively. The findings that are worth paying attention to are as follows. First, the wide variations in the number of indicators and sub-indicators from 0-11 and 0-22 reveal some difficulties in selecting appropriate/average numbers while establishing these tools. The absence of campus-wide, environmental and spatial-based sustainability indicators and sub-indicators in some of the tools raises suspicion, and the inclusion of a limited number shows the absence of considerations for these indicators over the years. Even though HEIs campuses worldwide are located in a vast land area with multiple activities and operations associated with severe ecological consequences. The low indicators and sub-indicators show that a more significant number of the tools are not multi-criteria in nature due to their inability to include CSA's diverse environmental dimension. This result contrasts with the findings from extant literature that emphasized multi-criteria assessment tools in appraising institutions with diverse land areas and complex activities such as HEIs.

2.6.1.2 Frequency of Categories, Indicators, and Sub-Indicators Usage

Although the ECS Broad List contains 13, 50, and 65 unique categories, indicators, and sub-indicators, respectively, the number of times these unique attributes appear or are utilized in more than one tool varies greatly. Utilizing an attribute in only one tool or more than one tool shows its level of importance and preference in appraising campus-wide dimensions of HEIs. The study's coverage evaluation outcomes reveal an absence of concurrence regarding the process of categories, indicators, and sub-indicators selection.

For instance, regarding the frequency of usage under the CSA tools categories hierarchy (Operation* and Environment*), both appear in three different categories. For the indicators' frequency of usage, (Environment*) appears six more times as indicators but only across two tools as it appears five times in one of the tools (i.e., DPSEEA-Sustainability index Model). The two indicators (Energy and Energy and Resources) having the same operational definitions. As for the sub-indicators, the two indicators (Energy efficiency and Energy efficiency measures) have a similar technical meaning. Three sub-indicators (Amount of energy used; Rate of depletion of energy resources; and Energy consumption) have the same technical meaning. Another two sub-indicators (Water consumption and Water Use) both have the same technical meaning. Also, the sub-indicators (Emissions, effluents, and waste; Production of emission, effluents, and waste) have a similar operational definition.

However, several other attributes are utilized literally or have similar operational definitions across the selected tools' hierarchies (categories, indicators, and sub-indicators). For instance, (Hazardous waste management) was utilized twice as a sub-indicators and once as an indicator. (Environmental improvement) was utilized in one of the tools as a sub-indicator, and (Environmental Management Improvement) was used as an indicator in another tool with both having the same operational definition. The frequency of usage results is an interesting one. I perceived the lack of a sound theoretical framework and crucial social media data across the globe to arrive at the selected attributes.

2.6.2 SMART Approach

Although, the deep coverage evaluation that reveals the extensive coverage of the indicators and sub-indicators in each of the tools is vital in obtaining a better representation of the individual attributes. It should be noted that deep coverage can be embedded with the repetition of indicators usage and appraisal or communication challenges due to large or complex data. Also, it can lead to an underrepresentation of other vital indicators. Therefore, there is a need to eliminate repeated attributes and striking of balance to ensure the inclusion of all essential attributes in the CSA framework. Therefore, the SMART approach was utilized to ensure that the ECS Broad List contains attributes that strike a balance between breadth of coverage and the inclusion of campus-wide indicators that could be adopted in GIS and related software.

Before the utilization of each characteristic of the SMART approach, the repeated attributes were merged as follows. Operation* and Environment* both appeared in three of the different categories of the existing 13 tools and were merged to make them both appear once under the theme of categories. However, Environment* appears six more times as indicators but only across two tools as it appears five times in one of the tools. The six Environment* indicators were removed as it has already appeared in the category theme. Environmental improvement that appears a sub-indicator was removed because it has the same operational definition as the indicator (Environmental Management Improvement). The two indicators (Energy and Energy and Resources) having the same operational definitions were both removed due to the appearance of Energy and climate as a broad category. Energy also appeared as a sub-indicator and was deleted. The (Energy efficiency and Energy efficiency measures) with similar technical meaning that appeared both as a sub-indicator were merged with the one that already exists as an indicator. The three sub-indicators (Amount of energy used, Rate of depletion of energy resources, and Energy consumption) seem to have the same technical meaning and, as such, were merge to Energy consumption.

The two sub-indicators (Renewable energy, and Clean and Renewable Energy) were merged with the indicator (Number of renewable energy sources in campus). Water appeared three times as category, indicator, and sub-indicator and was merged into one under the category theme. The sub-indicator (Water efficiency measures) merged with the indicator (Water efficiency) as they both have the same operational meaning. The two sub-indicators (Water consumption and Water Use) were merged as Water consumption as both have the same technical meaning. The sub-indicator (Emissions, effluents, and waste) is merged with (Production of emission, effluents, and waste). Transport* appeared four times. Three indicators and one sub-indicator (Transport*) were all merged with (Transport*) underneath the category theme. Hazardous waste management was mentioned three times. The two sub-indicators (Hazardous waste management) were merged with that underneath the indicator. Waste appeared three times and merged with the Waste underneath the category. The two sub-indicators (Waste Minimization and Diversion and Waste reduction) were merged as Waste reduction. Three sub-indicators (Production of greenhouse gases, Greenhouse gases, and Greenhouse Gas Emissions) were merged as Greenhouse Gas Emissions. This process reduces the attributes to 9 categories, 36 indicators, and 47 sub-indicators. The process of the SMART approach is discussed in the sub-sections that follow.

2.6.2.1 Specific Process

At the end of the filtering process, based on how specific nature of the indicators, five indicators (Ecology, Ecosystem, Basic Equipment, Facilities, and Resource consumption) and 19 sub-indicators (Materials, Biodiversity, Resources conservation, Recycling, Campus preservation, Exceedance of noise level, Changes in environmental conditions, Proportion of people exposed to poor air conditions, Proportion of people exposed to poor water quality, Proportion of people exposed to various hazards, Proportion of people exposed to high noise levels, Impact on energy resources, Effects on human health, Effects on environment, Effects on biodiversity, Other open space, Environmental performance, and Commute Modal Split) were removed from the list due to lack of specificity on the aspect of HEIs campuses. For instance, "impact on energy resources" is too generic without information about what is causing the impact. This approach reduced the attributes to 9, 31, and 29 categories, indicators, and sub-indicators, respectively.

2.6.2.2 Measurable Process

Under the category theme, the three categories (i.e., Sustainability on campus, Operations, and University EMS) were removed from the comprehensive list. They do not process specific numeric values or units. On the other hand, 11 indicators (Hazardous Waste Management, Non-Hazardous Waste Management, Environmental Procurement, Environmental Management, and Improvement, Green Campus, Operations and Management, Use of historical assets on campus, Organic waste treatment, Inorganic waste treatment, Toxic waste treatment, and Shuttle services) and 11 sub-indicators (Minimize negative impacts of operations, pollution prevention, Production and consumption of ozone-depleting substances, Increasing transport density, Percentage daily commute by motor vehicle and transport conflicts, Energy management, Indoor environment, Connecting with the local community, Building Design and Construction, Building Operations and Maintenance, Rainwater Management) were excluded from the list. This approach reduced the attributes to 6, 20, and 18 categories, indicators, and sub-indicators, respectively.

2.6.2.3 Achievable Process

Achievability is one of the essential characteristics of good sustainability indicators. An indicator that could not achieve will make the conclusions and findings of an appraisal process impossible. As such, it could be regarded as a hypothetical indicator. An achievable indicator should also be linkable to the exact and overall sustainability mission of HEIs without neglecting its stakeholders' participation. At this stage, all the indicators qualified the achievable process, and no reduction was made.

2.6.2.4 Relevant Process

During this phase, only three indicators (Global Climate, Composting, and Disaster prevention locations) were identified as not in line with the objective of spatial-based, environmental, and campus-wide planning and development principles of sustainable campus appraisal in Nigeria. They are not in line with this study's scope because the research aims to develop a local CSA appraisal model that will have the capacity to appraise spatial indicators that reflect and match the nature of HEIs in Nigeria. This justification is also in line with the World Green Building Council that encourages its representatives in each country to implement the sustainability concept related to green building or green campus according to their region's unique local conditions (World Green Building Council, n.d.). On the other hand, campuses of HEIs with the tenets of sustainability is a neighborhood that "*acts upon its local and global responsibilities to protect and enhance the health and well-being of humans and ecosystems*" (Cole, 2003 p.30).

2.6.2.5 Time-specific Process

Finally, similar to effective indicators' ability to be **m**easurable to quantify the campus development and sustainability level numerically with specific numeric value and unit. A noticeable difference within a specified period is also an essential characteristic of indicators for CSA. A significant indicator should have the ability to be adaptive to change and allow for the process of review or repeated within the short, medium, and long term. Also, all the indicators qualified at the end of this process, and no reduction was made.

Table 2. 3: Percentage of Indicators Coverage based on SMART Approach

Approach	Category	Indicator	Sub-indicator
Specific	100%	86.1%	61.7%
Measurable	66.67%	55.56%	38.3%
Achievable	66.67%	55.56%	38.3%
Relevant	66.67%	47.22%	38.3%
Time-bound	66.67%	47.22%	38.3%

Table 2.3 illustrates the SMART Approach results indicating the extent to which the indicators meet all the SMART criteria. All the attributes in the various categories meet the "Specific" criteria, while 66.67%

meet the remaining four criteria. As presented in **Table 2.3**, none of the indicators and sub-indicators across the tools meet 100% of the SMART criteria.

At the end of the SMART approach stage, the ECS Broad List hierarchy was restructured into two (i.e., categories and indicators), as shown in **Table 2.4** below. While the number of categories remains at 6, the sub-indicators were all moved to indicator themes, making it 35. This restructuring was carried out to eliminate some identified challenges of massive data requirement, complex appraisal process, and comprehension difficulties in the selected tools (Alghamdi et al., 2017).

2.7 Integrating GIS and or other Spatial Software into CSA Spatial-Based Model

The previous sections highlighted the need for a set of environmental indicators for CSA that have campus-wide and spatial dimensions (i.e., they can be linked to a spatial or geographical region). This section discusses how sustainability appraisal for HEIs campuses that are integrated with GIS and related spatial techniques. The demonstration of the integration uniqueness compared to other CSA tools, frameworks, and approaches is also discussed.

For the said purpose, it is recommended that GIS and or other spatial software should be utilized to developing a CSA model within its sphere of operations, mostly in developing countries. The endorsement of GIS and or other spatial software is primarily due to their application and ability to incorporate massive datasets within their program. Secondly, they have made more infiltration due to the increased awareness among policy and decision-makers to rely on these systems for public policy formulation. For instance, both computer-based systems, GIS and CityEngine, can process the data from various sources and integrate it with the geographical location while providing the user or the decision-maker with the information necessary for making informed decisions. The compilation, stockpiling, dissection, and presentation of the combination of topographical, ecological, and non-ecological data for specialized activities could be carried out on these spatial platforms. It must be kept in mind that these spatial tools are automated tools and work on human commands. To use these spatial techniques as tools for campus-wide sustainability appraisal of HEIs campuses, it is imperative to develop a logical and scientific model based on empirical evidence. The model as a whole shall be established on the indicators contained in **Table 2.4** that will ultimately reflect the overall sustainability assessment of academic institutions. The campus-wide indicator development and model building in spatial-based techniques are essential for generalizing academic campuses' sustainability assessment. Results can be presented to ultimate decision-makers in a most logical, comprehensive, and efficient manner (Geneletti, 2004).

The integration of these software with CSA can be helpful in two ways. Firstly, it can help in generating the data needed as input into the assessment framework. For example, the percentage of campus routes with campus fleet, flow planning, pedestrians, and cycling. Some scholars have designed a GIS-based tool for evaluating the walkability of a street network (Ble et al., 2014; Blečić et al., 2015). CityEngine was utilized as a 3-dimension GIS visualization technology to appraise urban sustainability and future sustainability scenarios in a city in Germany. Such a tool could be useful for adoption, incorporation, and modification for CSA. Likewise, GIS and other related techniques can help analyze provided data to generate more information. For example, the accessibility of facilities can be analyzed using GIS and the result input into the appraisal framework. Besides, these software infrastructures could be utilized to establish spatial-based sustainability indicators in the production of thematic maps to aid the visualization of the state of sustainability within a geographical location (Stylianidis, 2012). **Table 2.4** shows the proposed indicators related to operations and management of campus functions and space, thus having a spatial dimension. It indicates how GIS and other related spatial techniques could help measure the spatially-related indicators based on the structured coverage evaluation and SMART approach applied to the selected 13 analyzed CSA tools.

Table 2. 4: Spatial-based Campus Sustainability Indicators

Categories	**Indicators**	**The function of GIS and other related spatial software in spatial-based indicator measurement**
1. Environment	(1) Land (2) Public Space (3) Landscape (4) Greenspace and forest land (5) The ratio of open space area to the total area (6) Total area on campus covered in forest vegetation (7) Total area on campus covered in planted vegetation (8) Total area on campus for water absorption besides the forest and planted vegetation	- The acreage/area of green area, land, public space, and public space in m^2 - Area of heat islands in m^2
2. Setting and infrastructure	(9) Physical structure (10) Natural Heritage (11) Buildings (12) Green buildings	- Area of buildings, green building with Certified LEED, natural heritage and physical structure in m^2 - Location of green buildings/buildings, natural heritage, and physical structure
3. Energy and climate change	(13) Number of renewable energy sources in campus (14) Energy Efficiency (15) Greenhouse Gas Emissions (16) Building Energy Efficiency (17) Energy consumption (18) Air & Climate (19) Annual energy consumption rate (20) Concentration of greenhouse gases (21) Production of emission, effluents, and waste (22) Concentration of emissions, effluents, and waste	- Location of renewable sources, greenhouse gas concentration, emissions, effluents, and waste concentration - Energy consumption in kWh - Quantity of electricity per area of solar - Area and percent of buildings that generate greenhouse gases

		- Greenhouse gases in CO_2 equivalent
4. Waste	(23) Sewage disposal (24) Waste reduction (25) Construction and Demolition Waste Diversion	- Amount of waste disposal and reduction in m^3 and metric tons - Location of sewage disposal - Area of waste collection in m^2
5. Water	(26) Treated water consumed (27) Water efficiency (28) Water consumption (29) Rate of water consumption and quality (30) Amount of water supplied and distributed/collected for purification	- Amount of water in m^3/litres/$ft.^3$/gallons - locations of water supply - Area of water supply
6. Transportation	(31) Access for Handicapped People (32) Campus Fleet (33) Flow planning (34) Pedestrians and cycling (35) Green transportation	The dimension (1D, 2D, 3D) of cycling, pedestrian, ramp, and campus route in m/km/km^2

When the selected campus-wide and spatial-based sustainability indicators are integrated into the spatial data infrastructure system, they will generate a set of appraisal reports associated with a unique campus location. In line with the principles of national spatial strategy, location and its surroundings are essential factors in the CSA framework. This framework cannot be executed in isolation without due regard to location. It will provide the relevant connection within the site, spots, area, and sustainability components of structures and other facilities within the geographical boundary of HEIs campuses. This connection will help in focusing on the energy and resources needed to attain maximum campus sustainability standards. Also, unlike the 13 CSA tools reviewed in this study, the proposed framework will provide a comprehensive spatial and non-spatial database for HEIs. This digital database will be beneficial as values or quantities of specific indicators could be altered to regularly appraise sustainability performance in HEIs. It will also reduce economic costs and assist in the evaluation and review process.

Similarly, the proposed framework can provide the HEIs administrators and management with ample room to evaluate a different sequence of events and master plan implementation. Spatial software empowers the operators with the capacity to observe different scenarios encouraged by using various specifications. Environmental-dimension indicators with campus-wide and spatial attributes could be worked upon to view any strategies' different results. These measures and strategies can be appraised before implementation to save valuable costs and time. The difference between the reviewed CSA tools and this study's proposed framework is demonstrated in **Figures 2.3 and 2.4**.

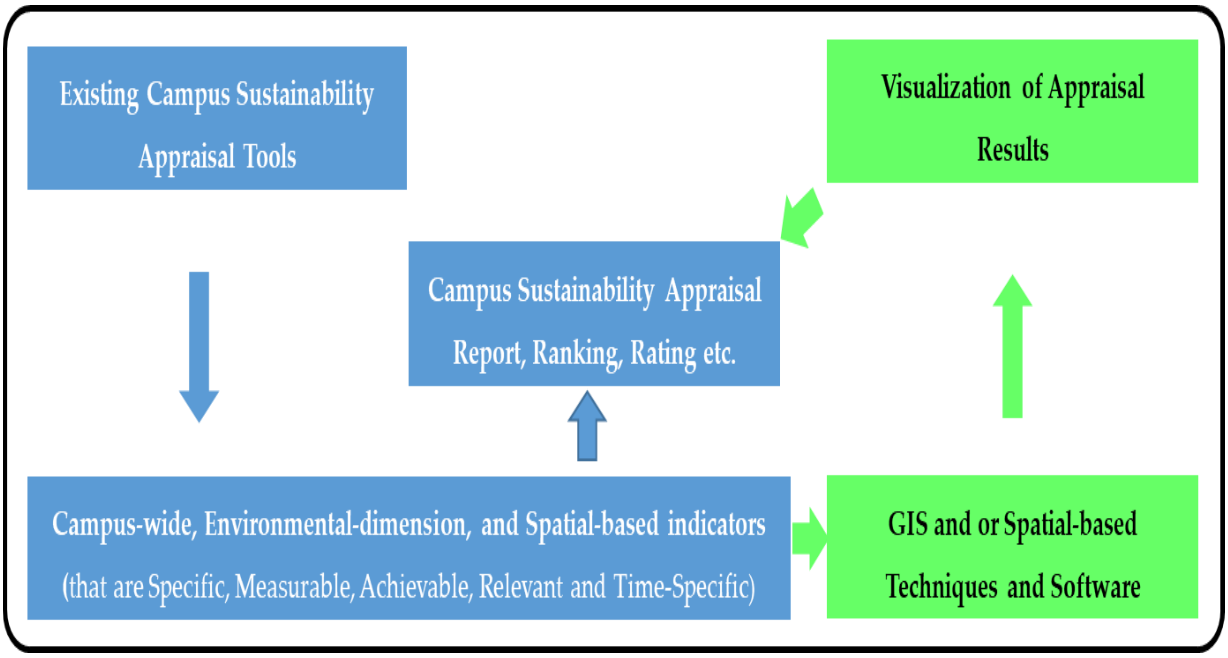


Figure 2. 3: Proposed Framework Integration into the Existing Tools using Schematic Image

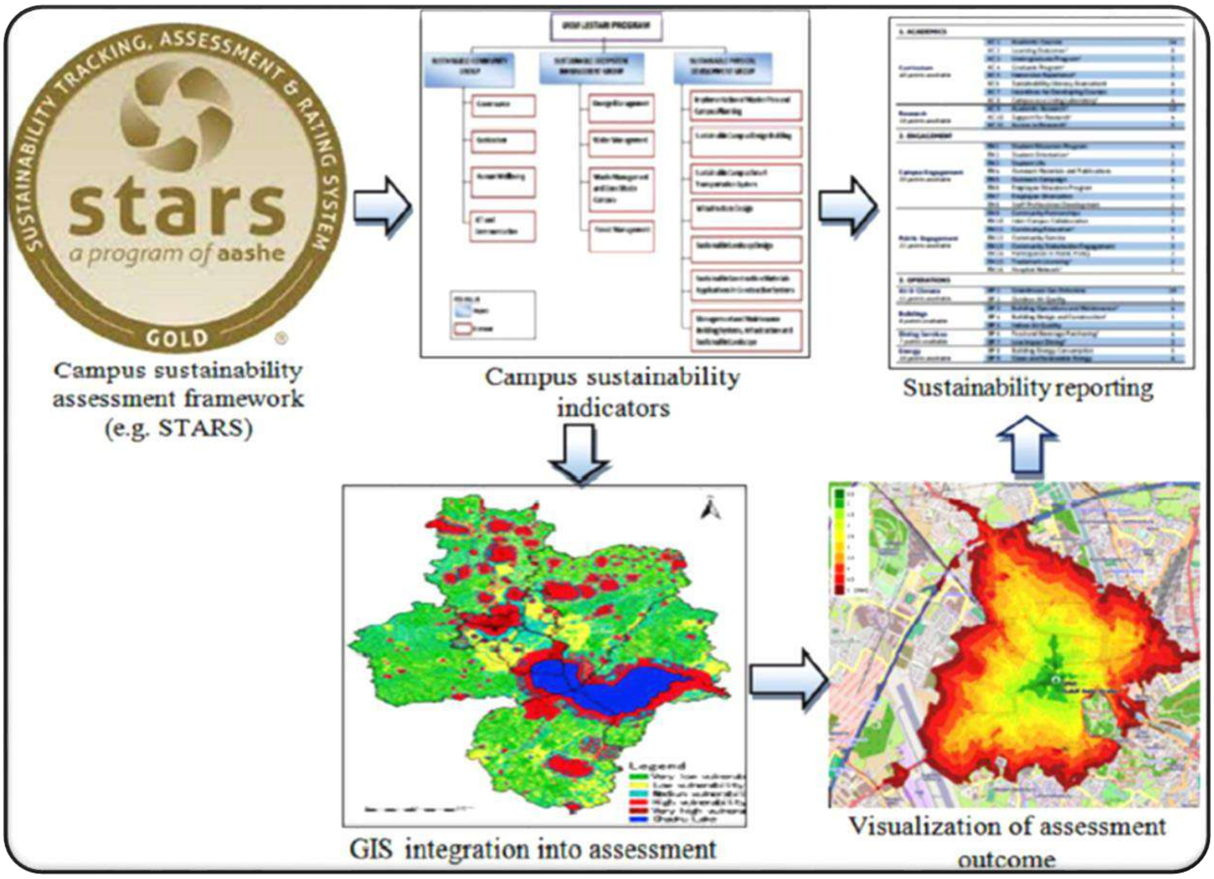


Figure 2. 4: Proposed Framework Integration into the Existing Tools using Graphical Image

In the analyzed CSA tools, despite the existence of environmental-dimension indicators with spatial and campus-wide attributes, the appraisal process mainly involves the sustainability performance evaluation of selected indicators with the outcome in the form of reports, ranking, rating, awards, etc. However, by incorporating the proposed spatial-data infrastructure system based on spatial software, the appraisal process will entail spatial visualization technologies to reveal the current and future scenarios of campus-wide sustainability performance, citizen involvement in the appraisal, planning, and decision-making process.

The 13 analyzed tools' coverage evaluation reveals that the data sources for indicator selection are mostly from existing tools and models, literature review, surveys, workshops, internet sources, development processes, and HEIs with sustainability initiatives. Also, the opinions of selected professionals were used in arriving at their preferences. Although three analyzed tools (i.e., TUR, Graz, and STARS) utilized social media platforms (i.e., Wikipedia, Facebook, Twitter, and Interactive blog) in data sources for indicators selection, there is the need for more utilization of citizen/stakeholders participation via social media to improve the process of developing and selecting indicators for CSA.

This study recommends utilizing a novel method involving the use of data from social media to arrive at the preferences of HEIs stakeholders on environmental-dimension indicators with spatial and campus-wide attributes. The data could be extracted and analyzed using scrapping tools and programming language to mine from social media application program interfaces or libraries. Twitter, one of the current various available social media platforms, has been helpful in discussing sustainability in academic campuses and several related topics. Data on Twitter currently contain relevant and pragmatic information for the planning and implementation of campus sustainability strategies based on the major stakeholders' preferences. As such, it can be deduced that with the ubiquitous electronic gadgets with an internet connection, several million active Twitter users across the globe, stakeholders' preferences on campus sustainability indicators should be carried out based on social media data with a robust theoretical basis.

Lastly, citizen participation options are available in ESRI's spatial technique platforms allowing for a participatory appraisal mechanism. The public participation platform options have not yet been utilized in CSA despite their potential in advancing the process of developing and selecting indicators.

2.8 Conclusion and Future Direction

This chapter utilized mixed methods of (i) coverage evaluation and (ii) a SMART approach to explore the coverage practices of campus-wide, environmental-dimensions, and spatial-based indicators in appraising campus sustainability from 13 existing CSA tools. The outcomes reveal an absence of these nature of indicators and variations in their usage and selection. These variations can lead to the difficulties of arriving at uniform appraisal ratings of several campuses. However, with this study's proposed framework, different campuses could be appraised across the world, limiting the indicators to each campus's relevance. Adapting selected spatial-based indicators to a specific campus does not need a complex and challenging to comprehend process. Instead, the ECS Broad List filtering using the

SMART approach. This finding illustrates a tremendous improvement can be adopted, utilized, or modified to fill the research gap identified in the literature regarding lack of or restricted access to data, choosing a set of indicators, and difficulties in indicators appraisal. These challenges could be minimized with the integration of the GIS and or other Spatial Software into the CSA spatial-based framework. This chapter presents the initial attempt toward developing a CSA framework for HEIs in Nigeria. The 2009 Abuja Declaration recommends the appraisal of the sustainability performance of HEIs in Africa. Discussions of the process of other proposed frameworks will be provided in the following chapters. A pilot study and a case study for test-running and validating the proposed model within the context of HEIs in Nigeria will also be discussed in the subsequent chapters.

2.9 Chapter Summary

Despite the plethora of comprehensive reviews of campus sustainability assessment tools, reporting, and indicators in the extant literature, studies are absent specifically on campus-wide and spatial-based indicators in existing tools. Although several academic campuses worldwide are located in a vast land area with multiple activities and operations associated with severe ecological consequences. This chapter explores the environmental-dimension indicators with spatial and campus-wide attributes in 13 existing campus sustainability appraisal tools via coverage evaluation and the SMART approach. The findings reveal a severe absence of comprehensive coverage of spatial-based indicators and the lack of integrating a GIS and or related spatial software in their appraisal process. The chapter demonstrates how integrating GIS and or other related spatial techniques and software into environmental dimension indicators with campus-wide and spatial attributes could be carried out to remedy the challenges of absence, inadequate of, or restrained access to essential information for campus sustainability appraisal project in Nigeria.

CHAPTER 3: TOWARDS THE DEVELOPMENT OF A FRAMEWORK INTEGRATING SOCIAL MEDIA UGC INTO CAMPUS ENVIRONMENTAL SUSTAINABILITY APPRAISAL[3]

3.1 Chapter Overview

In Chapter 2, a comprehensive review of 13 existing tools for the appraisal of HEIs was reviewed to identify their environmental-dimension indicators coverage. **Section 2.7**, titled "Integrating GIS and or other Spatial Software into CSA Spatial-based Model," recommends utilizing data from social media to arrive at HEIs stakeholders' preferences on environmental-dimension indicators with spatial and campus-wide attributes was proposed. In this chapter, an extensive review of the extant tools was conducted to understand the extent to which social media data and platforms have been utilized. The outcomes led to the proposal of a framework linking social media to environmental CSA.

3.2 Introduction

Social media can be referred to as "*a group of Internet-based applications that exist on the Web 2.0 platform, and that enable Internet users from all over the world to interact, communicate, and share ideas, thoughts, experiences, information, and relationships*" pg. 12 (Leung et al., 2013). During this age of social media prevalence, the internet allows citizens and stakeholders to participate in essential issues (Li et al., 2011; Thevenot, 2007) like environmental CSA rather than the initial role of only information dissemination. For instance, an average of 5 million tweets and 3 million Flickr images are shared by users worldwide daily (Bodnar, 2020). In addition to several million dissipated across several other social media platforms, these tweets and images reveal social media's relevance in addressing ecological-related sustainability practices and performance in our HEIs campuses in the present age.

[3] This chapter is partly published in:
Adenle, Yusuf A., Abdul-Rahman, M., Soyinka, O.A., 2021. Exploring the usage of social media in extant campus sustainability assessment frameworks for sustainable campus development. Int. J. Sustain. High. Educ. https://doi.org/10.1108/IJSHE-03-2021-0091

With the appearance and ubiquity of social media amongst HEIs staff, students, and other important HEIs stakeholders, reliance on traditional data outlets or few experts for environmental sustainability appraisal seems inadequate at this age. Adopting an appraisal tool for utilization in HEIs or certain countries can be confronted with numerous challenges, such as a lack of an apparent realization and awareness of most stakeholders' perceptions. Hence, social media platforms with information or designed explicitly for HEIs have a high percentage of reflecting the users' opinions and assisting with CSA's valuable data.

By studying and assessing the information provided on social media platforms on campus-wide environmental sustainability and other related issues, HEIs authorities could understand what their stakeholders are complaining about and the ecological indicators with higher or fewer preferences. Their comments, reviews, and sentiments can also assist in HEIs' environmental-dimension sustainability performance comparison. Indeed, several HEIs are beginning to incorporate different social media platforms into their websites to improve participation, information dissemination, and collaboration. In Asia, examples of HEIs with links to different social media platforms include but are not limited to the Hong Kong Polytechnic University in Hong Kong and the King Fahd University of Petroleum and Minerals in Saudi Arabia. In Nigeria, sub-Sahara Africa, the University of Lagos website has a direct link to its official Twitter and Facebook page. Most of these HEIs are interested in learning and advancing their environmental-related indicators sustainability performance for QOL via listening and interacting with their stakeholders through social media platforms like Instagram, WeChat, Facebook, and Twitter.

With the rise of social media utilization across various disciplines and the dearth of research articles on social media data usage in assessment tools and campus sustainability framework, a research question was asked to fill the identified knowledge gap. This study's research question is: "*What have the developers and scholars of existing CSA tools carried out concerning social media data?*" With the continuous popularity and acceptance of social media in several HEIs globally, a review of existing CSA tools' documents is needed. Therefore, this study reviews the existing CSA tools to identify their social media utilization in campus sustainability indicators selection and indicators' data collection.

This review will help identify the various roles social media has contributed and would be paramount in advancing the social media progress and practicality in CSA environmental-based projects. Several studies justifying the relevance of review analysis have been carried out. The outcomes of this chapter will significantly contribute to CSA discussions. Aside from the provisions of answers to the study's research question, this chapter also aims at contributing to future direction on the use of social media in appraising the preferences of environmental-dimension indicators in HEIs in sub-Saharan African countries. Lastly, studies have recommended the use of social media in HEIs (Hamid et al., 2017).

3.3 Literature Review

3.3.1 The Need for Social Media UGC in CSA

Studies on campus planning, development, appraisal, and infrastructure design for sustainability have been driven by HEIs programs, United Nations Educational, Scientific, and Cultural Organization (UNESCO), Sustainable Development Goals (SDGs), and Declarations conferences and workshops, and CSA tools. The CSA tools are a powerful, pragmatic, and efficient mechanism for evaluating and assessing the influence of campus environmental development policies, infrastructure, and information management systems (Gomez et al., 2015). Therefore, CSA tools' significance arises from being an appropriate tool that provides a comprehensive information base on environmental data for HEIs authorities, policymakers, and campus planners. For instance, environmental CSA exercise results are useful for policymakers and other decision-makers to measure their policies and development actions concerning environmental or ecological indicators with management procedures. For these decision-makers, the CSA tools represent a successful tool to (i) examine the sustainability practices of HEIs and campus-wide planning processes, (ii) monitor changes in HEIs stakeholders' perceptions of priorities for improving QOL on campus, and (iii) set priorities and seek direction for the future sustainable infrastructure development.

On the other hand, a sustainable university is defined by Velazquez and colleagues as follows: ''*A higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles*''p.30 (Velazquez et al., 2006). CSA tools "*have been used for more than a decade, as tools for identifying best practices, communicating goals and experiences, and measuring progress towards achieving the concept of a sustainable campus*" p.2 (Sonetti et al., 2016). The expanding interest in initiating and utilizing CSA tools happened due to the well-described socio-economic and environmental advantages that the practice's adoption has brought about. An ancient proverb says, "*what doesn't get measured doesn't get managed.*" HEIs campuses can also be referred to as urban areas or, better still, smaller-scale cities because they possess diverse coverage areas, different land uses as well as a wide variety of activities similar to that of cities (Alshuwaikhat & Abubakar, 2008). Therefore, HEIs also require the same level of campus-wide environmental sustainability assessment for a quality lifestyle similar to that of cities.

Several international treaties and declarations have encouraged HEIs to incorporate sustainability initiatives into daily operations and activities (Grindsted, 2011; Grindsted & Holm, 2012; Lozano et al., 2013; Tilbury, 2011; Wright, 2004). Examples include the 1972 Stockholm Declaration on the Human Environment, the 1990 Talloires Declarations, the 2002 Ubuntu Declaration, the UN Decade Education for Sustainable Development 2005-2014, the Abuja Declaration on Sustainable Development in Africa: The role of higher education in sustainable development, and the People's Sustainability Treaty on Higher Education. Also, various CSA tools, frameworks, and techniques have been developed over the years to monitor and assess the integration of the level of sustainability within HEIs campus daily activities and operations (Alghamdi et al., 2017; Lozano, 2006; Shriberg, 2002a; Yarime & Tanaka, 2012). Examples of such frameworks and techniques include but are not limited to the UEMS, TUR, AISHE 2.0, Graz, Green Metric, D-SiM, and AMAS.

The development of these different CSA tools, frameworks, techniques, and proclamations of several global declarations and treaties encouraging the integration of sustainability concepts into HEIs has made different HEIs commence tracking their ecological and environmental-dimension sustainability performance. HEIs can track the magnitude at which they are performing either positively or negatively based on the following seven criteria which are: (i) campus operations; (ii) society collaboration and outreach (iii) education; (iv) research (v) institutional framework; (vi) sustainable via experiences on campus, and (vii) reporting and assessment which is the scope of this research (Lozano et al., 2015a).

However, several weaknesses have been identified in using the different CSA tools being used in several HEIs to track the level of environmental and ecological-dimension sustainability performance in their campuses. In their review of some CSA tools' major cons, Alghamdi and colleagues found that the SAQ lacks comparison mechanisms (Alghamdi et al., 2017). Simultaneously, the time required to conduct sufficient documentation using the SUM and the SCAS is lengthy. They also stated that the GASU and The Green Plan require a large dataset in conducting CSA. At the same time, the social pillar of sustainability is not covered in BIQ-AUA, USAT, and SCAS. Also identified is the substantial financial cost required by HEIs to participate and become a registered member before utilizing STARS as another significant weakness. Bice and Coates also noted that the GRI lacks depicting the social aspects of institutions' sustainability (Bice & Coates, 2016). Shi and Lai noted that the meaningfulness of STARS comprehensive criteria is affected by redundant criteria (Shi & Lai, 2013). Urbanski and Filho posited that the use of STARS at the HEIs is still at an early stage, and more efforts are still needed to make it more acceptable to institutions (Urbanski & Filho, 2015).

Also, the adoption of these CSA tools at different levels are associated with different shortcomings such as non-integration of CSA with spatial techniques and software (Adenle et al., 2020; Alshuwaikhat et al., 2017), lack of global and national comparison mechanism (Sonetti et al., 2016), difficulties in understanding the assessments, and large data requirement (Alghamdi et al., 2017). However, a review of the utilization of social media data in the existing CSA tools is lagging in extant literature. Hence, the need for this research. With most social media applications' interactive and collaborative configuration, information generation with enhanced content is achievable due to end-users active participation (Kaplan & Haenlein, 2010). In the same context, HEIs stakeholders can actively participate in generating campus-wide ecological and environmental indicators sustainability-related information on the internet. Finally, some scholars recommended that advocacy and awareness creation on social media's usefulness in sustainability within HEIs be promoted (Carpenter et al., 2016; Hamid et al., 2017).

3.3.2 Existing Tools for Social Media Big Data Mining

Although the use of social media big data mining software are incorporated with specific technical threshold, it has been observed that many computer scientists and programming language writers found the writing of codes on using these software fascinating. Some of the technical thresholds for social media data mining require that the researcher have a python programming language. In a campus-wide environmental impact assessment project involving different environmental specialists, the HEIs project planning management might need to extract the prospective project consortium. The reliance of the project management on the search engine or viewing information on the relevant web pages will be very time-consuming and laborious. On the other hand, the cost of learning to write on software like a reptile is too high if they have no programming foundation. However, it will be wise for them to go to the line and write codes if they know these programming tools. This scenario also applies to researchers/scholars conducting CSA using social media data. Therefore, it is conducting social media research using visual reptile tools that will be a feasible option.

There are a few visual reptile tools that are available for use. These tools use some strategies to crawl specific data. Although researchers using them do not have to write reptiles accurately, the learning cost is much lower. Below is a literature review comparing and analyzing ten visual reptile tools to help choose the most suitable reptile and experience social media big data mining for campus environmental sustainability with ease.

The first visual reptile tool for review is the tool known as a locomotive. As the old generation of the collection industry, the locomotive is an Internet data capture, processing, analysis, mining software that can capture the scattered data information on the webpage and accurately extract the required data through a series of analyses and processing (Costagliola et al., 2018). Its user positioning is mainly a crowd with a specific codebase suitable for programming veterans. The collection function is perfect, with no limit to webpage and content; any file format can be downloaded. It has an intelligent multi-identification system and optional verification methods to protect security. It supports Hypertext Preprocessor (PHP) and C# plugin extensions, and it is easy to modify processing data. It has synonymous, synonym replacement, parameter replacement, and pseudo-original essential skills. This tool's challenges are that it is difficult to collect and difficult for users with no programming basis. In summary, the tool is suitable for programming experts. The rules are more complicated to write, and the software's positioning is more professional and precise.

The second tool is known as Octopus. It is a visual, program-free web page capture software that quickly extracts standardized data from different websites to help users automate data collection, editing, and standardization, reducing work costs (Fan et al., 2017). Cloud capture is a significant feature of this software. When compared to other acquisition software, cloud capture can be more accurate, efficient, and large-scale. The software uses visual operation; it does not require code writing, makes rule collection, and is suitable for users with zero programming. Version 7.0 of the tool is intelligent, built-in intelligent algorithm, and established collection rules. Users can set the corresponding parameters to achieve the automatic collection of websites and Apps. Cloud acquisition is its primary function; it supports shutdown collection and achieves automatic timing acquisition. It also supports the multi-IP dynamic allocation and verification code-cracking to avoid IP blocking. Finally, it collects data, supports multiple export methods, and imports websites. In summary, Octopus is a collection software suitable for small white users. The cloud is powerful, and of course, the reptile veteran can also develop its advanced features.

The third tool that has been reviewed is called Episode of search. It is an easy-to-use web page crawler that crawls web page text, charts, hyperlinks, etc. It can also be collected through a simple visualization process to serve anyone who needs to collect data. Visual process operation, unlike Octopus, collects search focuses on defining the data and crawling routes. The rules of the Octopus are unambiguous, and the user decides each step of the software. It supports crawling data floating on the index chart and also crawling data on the mobile website. Members can help each other to improve collection efficiency, and template resources can be applied. In conclusion, the collection of search operations is relatively simple, suitable for primary users. There are not many features in terms of functions, and there are more follow-up payment requirements.

The fourth tool is called Archer cloud reptile. It is a novel cloud-based online crawler/collector based on Archer's distributed cloud crawler framework to help users quickly access many standardized web page data. It has direct access to proxy IP to avoid IP blocking. It allows automatic login verification code identification; the website automatically completes verification code input. It generates icons online and collects results in rich tabular form. It also has localized privacy protection, cloud collection and can hide user IP. In summary, the archer is similar to a crawler system framework. The specific collection requires the user to write the crawler, which requires a codebase.

The fifth tool that was reviewed is known as Madman collector. It is a set of professional website content collection software that supports various forum posts and reply collections, website, blog article content capture, sub-forum collector, CMS collector, and blog collector. It also supports batch replacement and filtering of text, link content in article content. Researchers using this tool can post in bulk to multiple sections of a website or forum. With the automatic shutdown function after the acquisition or posting task is completed. In summary, the tool focus on the crawling of forums and blog texts, and the versatility of collecting data on the whole network is not high.

Import.io (Lei et al., 2017), a web-based web data collection platform that allows users to generate an extractor without writing code, is the sixth tool reviewed. Compared to most domestic acquisition software, Import.io is smarter, able to match and generate a list of similar elements. The user input Uniform Resource Locator (URL) can also collect data with one click. It provides cloud services, automatically assigns cloud nodes, and provides a software as a service (SaaS) platform to store data. It also provides an Application programming interface (API) export interface to export Google Sheets, Excel, Tableau, and other formats. Its charging method provides the basic, professional, and enterprise versions according to the number of collected items. In summary, Import.io is intellectual development, easy to collect, but the processing power of some complex web pages is weak.

The following tool for mining data that was reviewed is called Octoparse. It is a full-featured Internet capture tool with many built-in tools that allow users to collect structured data from complex web structures without writing code (Ahamad et al., 2017). The collection page is designed to be friendly and straightforward, fully visualized for beginner users. It provides a cloud collection service, which can achieve 4-10 times speed cloud acquisition. It has an advertising blocking function to improve collection efficiency by reducing load time. It also provides XPath settings to locate elements of web page data accurately. Besides, it supports exporting multiple data formats such as comma-separated value (CSV), Excel, XML, etc. It has a multi-version selection divided into the free version and the paid version. The paid version provides cloud services. In summary, Octoparse is fully functional and affordable and can be applied to complex web structures. For research such as CSA of social media users that requires extracting social media data from Amazon, Facebook, Twitter, Instagram, and other platforms, Octoparse is an option.

Another data mining tool that was reviewed is known as Visual Web Ripper. It is an automated web crawler that supports a variety of features. It is suitable for some advanced and challenging to collect web page structures, but the users need to have strong programming skills (de S Sirisuriya, 2015). It can extract various data formats (list page). It provides an IP proxy to avoid IP blocking. It also supports multiple data export formats or customizes the output format through programming. It has a built-in debugger to help users customize the acquisition process and output format. It can be summarized that

Visual Web Ripper is powerful, customizable, and suitable for users with rich programming experience. It does not provide cloud collection services and may limit collection efficiency.

The second to the last mining tool that was reviewed is Content Grabber. It is one of the most powerful web crawlers. It is more suitable for people with advanced programming skills, providing many powerful script editing and debugging interfaces. It allows users to write regular expressions instead of using built-in tools. It has a built-in debugger to help users debug code. It is docked with some software development platforms for users to edit crawler scripts. It also provides an API export interface and supports a custom programming interface. In summary, the Content Grabber webpage is highly adaptable and powerful and does not fully provide users with essential functions suitable for people with advanced programming skills.

The last tool is called Mozenda. It is a cloud-based data acquisition software that provides users with many useful features, including data cloud reserve capabilities (de S Sirisuriya, 2015). It can extract various data formats, but handling irregular data structures such as lists and tables is challenging. It has a built-in regular expression tool, and it requires the user to write it themselves. It also supports multiple data export formats but no custom interface. In conclusion, Mozenda provides data cloud reserves, but dealing with complex web page structure and software operation interface jumps is challenging. Its users' experience is not friendly enough, and it's suitable for people with essential crawler experience.

The review of the selected tools above shows that the data on various social media platforms can be utilized when effectively incorporated in CSA appraisal.

3.4 Methods

The rise in CSA tools by various HEIs in different parts of the continents to monitor the signs of progress on aspects relating to sustainability in their campuses meant that their reports or published articles are significant to ecological and environmental policymakers. Access to these technical reports and articles might allow for the advancement of research based on the identified research gaps, future research direction, and avoiding repeating what has already been done. Identifying recent research outcomes and future research trends in any area of specialization via a comprehensive analysis of literature is essential to researchers in identifying research gaps (Tsai & Wen, 2005).

Over the years, several reviews of CSA tools, articles, and reports have been conducted. Ceulemans and colleagues carried out a comprehensive review of articles on sustainability reporting and appraisal tools in HEIs (Ceulemans et al., 2015). Others all compared different CSA tools based on their strengths and weaknesses (Kamal & Asmuss, 2013; Shriberg, 2002a; Sonetti et al., 2016; Yarime & Tanaka, 2012). Alghamdi and colleagues also carried out a general review of twelve CSA tools focusing only on CSA tools' indicators. Their review shows many research gaps and challenges that required serious attention by the HEIs community (Alghamdi et al., 2017). Their findings also reveal that since the first declaration of sustainability in higher education in 1972, there are still many significant CSA concerns for future research.

Figure 3.1 shows the research design illustrating the two stages involved in this chapter. In the first part, a comprehensive review and content analysis were carried out to progress on social media coverage studies in existing CSA tools. Based on stage one's outcomes, and the need to resolve the identified research gaps, a CSA framework incorporating social media platforms and data was proposed at stage two. The future utilization of the proposed framework and social media in CSA tools in sub-Saharan African nations was discussed. The following sub-sections detailed the methods involved in the two stages.

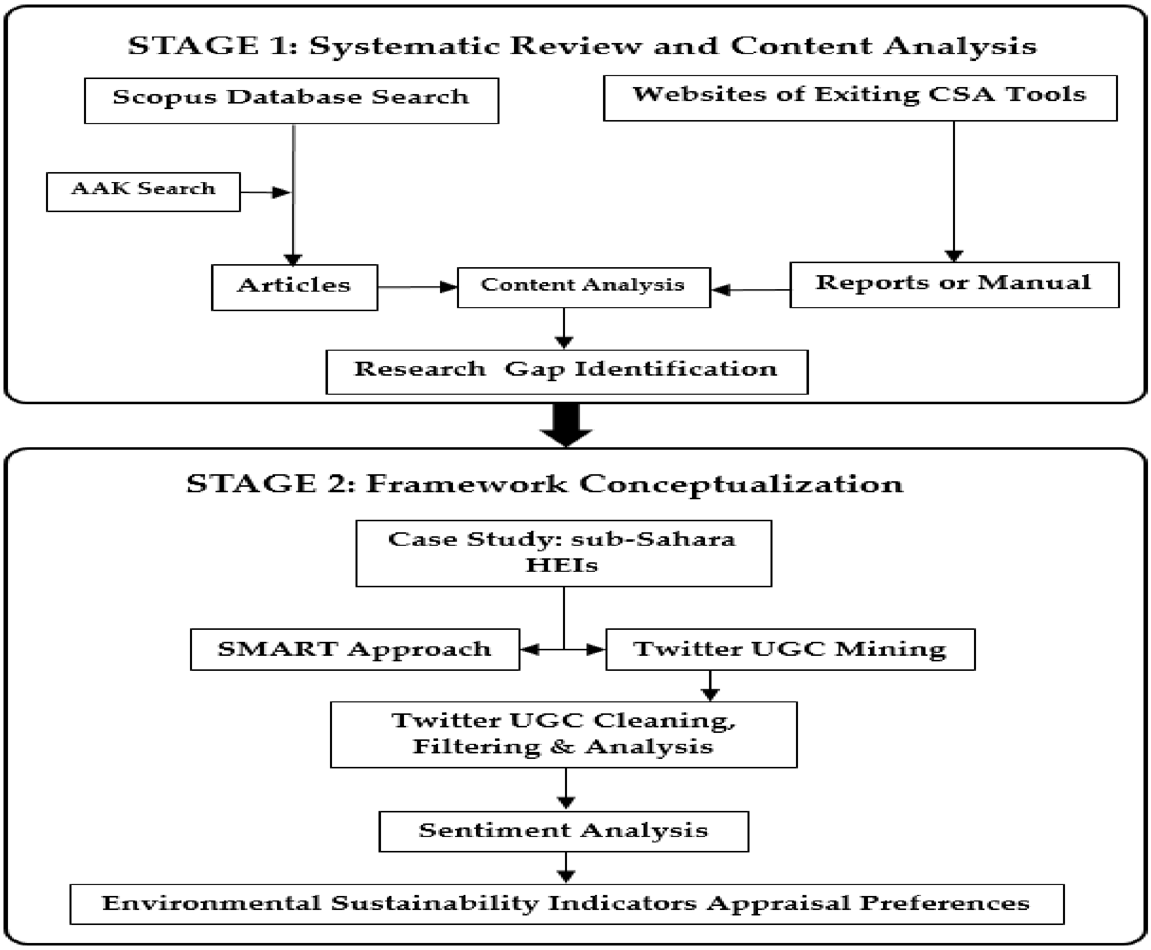


Figure 3. 1: Research Design Illustrating the Stages Involved in this Study

3.4.1 Systematic Review and Content Analysis of Extant CSA Tools

Denyer and Tranfield define a systematic review as "*a specific methodology that locates existing studies, selects and evaluates contributions, analysis, and syntheses data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known*" p.671 (Denyer & Tranfield, 2009). A systematic review was conducted based on a content analysis of existing tools documents after conducting a database search and their official websites to broaden the understanding of social media in CSA research. Firstly, an in-depth search was carried out based on the "Scopus" database search field of "Article title, Abstract, Keywords" (AAK) to identify CSA tools documented in article format from 1972 to 2019. Scopus database was selected to extract these published articles due to its more comprehensive coverage of the publication database (Bice & Coates, 2016). Another search engine (i.e., Google Scholar) was also utilized for the desktop study. The search ensures that the publications with terms within the scope of CSA in the article title, abstract, and keywords were considered worthy of critical analysis in this research. After that, the authors examined the websites of well-known and widely used existing CSA tools to obtain their available reports and or technical manuals.

The result reveals several thousand papers written on social media in HEIs with few campus sustainability papers. As this research aims for CSA tools, the search was restricted to documents with this specification. At the end of the first stage documents selection phase, 13 of the existing tools (see **Table 3.1**) were selected for content analysis regarding social media utilization or adoption in their appraisal process. The 13 existing appraisal frameworks were selected because: (i) they are all available in the English language. Manuals and articles of the existing CSA available in languages other than English, such as those written in German, Spanish, and French, were excluded for content analysis. (ii) they are indicator-based appraisal tools. This selection of only indicator-based tools ensures content analysis of how the indicators were selected and how the verification or case study appraisal data was collected. (iii) they are developed to be used within HEIs. Since this study focuses on HEIs, tools with metropolitan/city scope, appraisal of commercial institutions were excluded. This selection of only HEIs-based appraisal tools also led to the exclusion of several tools like the GRI. However, tools that derived their indicators from non-HEIs assessment tools/frameworks were considered since they are explicitly designed for HEIs. (iv) they are all accessible for content analysis and comprehensive review in either published articles, reports, or technical manuals. The well-known CSA tools in which neither their manual nor technical report was made available on their websites were excluded.

3.4.1.1 Environmental-dimension Attributes, Social Media Utilization, and Analyzed HEIs

Most of the CSA tools are developed to monitor indicators that constitute the three pillars of sustainability in HEIs and can be conceptualized and operationalized for accurate measurement. The tools often start with a long list of significant aspects of campus sustainability indicators, and those aspects are mainly subdivided into several sub-indicators. The significant aspects could be referred to as domains, categories, criteria, etc. The main attributes usually contain several sub-categories called indicators (Dijkers, 2003). Both categories and indicators are merged mainly by what is known as the conceptual framework/model that describes the relationship between all categories and indicators (Waheed et al., 2011). These frameworks are essential for most CSA tools to appraise environmental-dimension sustainability performance on campus effectively. The selection of appropriate categories and the indicators underneath these categories to no small extent also determine the degree of success of specific CSA tools. Therefore, to take much time as to define precisely what are the ethical aspects accepted as domains for a particular study depend on (i) its purposes, (ii) the accurate indicators that reflect these categories, and (iii) the degrees and shapes of linkages between these categories and indicators. Once this fundamental framework has been established, there is an assertion that the campus-wide sustainability performance and progress in HEIs can be measured and monitored to ensure their full potential.

As already discussed in Chapter 2, a broad list of all HEIs sustainability attributes was extracted from all the selected CSA tools; after that, attributes with socio-economic and other related pillars were excluded. The exclusion criteria limit the campus sustainability indicators and sub-indicators to only environmental-dimensions categories, which is the focus of this study. After analyzing the content of the selected tool documents, the tools with social media platforms were identified, and the contextualization of the number of countries and HEIs based on the CSA tool with sustainability attributes with environmental dimension and social media platforms was carried out. However, in this chapter, a framework demonstrating social media utilization for appraising the environmental indicators preferences in sub-Saharan Africa was proposed.

3.4.2 Framework to Measure Campus-wide Environmental Attributes Based on Social Media

Cities and campus planning have witnessed some improvements within the last years due to ICT advancement (Horita et al., 2009). This ICT advancement is most visible in the aspect of effective communication, collaboration, and citizen participation in decision-making. Many scholars have agreed on the development of ICT from a passive web to an interactive social platform (Misirlis & Vlachopoulou, 2018) among stakeholders in the HEIs industry as a great significance. Social media platforms provide better-detailed information on the nature of campus-wide sustainability events, courses, initiatives, infrastructure, etc., compared to other sources of information (Isacsson & Gretzel, 2011).

The utilization of social media UGC in environmental CSA is essential due to the enormous amount of information from various relevant stakeholders. Data collection via social media is also economical with less time-consuming. However, these UGC are generated on different social media platforms in volume ranging from several thousand to millions, with many contents unrelated to environmental sustainability indicators within HEIs. Also, different platforms are designed with unique programming interfaces with different approaches to content generation. The proposed social media platform for UGC mining and analysis of estimate sentiment orientation is Twitter, the highly utilized social media platform in social science-related studies (Abdul-Rahman et al., 2020). However, unlimited access to UGC extraction via the various Twitter APIs cannot be achieved due to its restrictive nature.

A simplified framework based on free, open-source software was proposed to avoid Twitter UGC mining via its APIs and ethically retrieve its users' UGC to appraise environmental sustainability indicators preferences and performance. This proposed framework reduces the time and financial cost required by most existing tools in data collection, appraisal, ratings, and ranking. It also aims to provide CSA tool developers and scholars with basic programming knowledge to utilize the strengths of artificial intelligence, big data, accessible data mining tools, and open programming software in planning, designing, and appraising sustainable campuses. The proposed framework is based on the following approach:

Firstly, Twitter UGC Mining. This mining process entails the extraction of UGC from HEIs Twitter accounts within the sub-Sahara Africa via open-source phyton libraries and elastic stack. Using this approach, the mined UGC could be stored in a SaaS storage platform, external storage devices, internet development, etc. Secondly, the SMART Approach. In ensuring that the identified environmental sustainability indicators meet the specific institutions' requirements within the context of HEIs in sub-Sahara Africa, the SMART approach that guarantees the selected indicators are specific, measurable, achievable, relevant to the local context, and time-bound is also proposed.

Thirdly, UGC Cleaning and Filtering. This process involves limiting the enormous extracted UGC to only those that have gone through the identification and selection via the SMART approach. This stage also entails converting the mined UGC in CSV file format (which makes data analysis difficult using Elastic stack software) to other file formats such as JavaScript Object Notation (JSON) and new-line (nlJSON) using a basic python programming language. This stage also helps set the stage for convenient analysis of the identified environmental sustainability attributes in line with the nature and challenges of the selected HEIs.

Lastly, the Sentiment Analysis. Studies show that extant tools mostly rely on a small expert sample size to obtain the perceptions and indicators' level of importance using various multiple criteria decision-making techniques. However, in this proposed approach, opinions, views, reviews, and complaints of huge relevant HEIs stakeholders can be analyzed through the various machine learning tools. This study proposes Azure Machine Learning software to clean and analyze the case study's online users' sentiment orientation on every selected environmental sustainability indicator.

Besides the sentiment analysis outcomes, the frequency of Twitter comments, likes, shares, and forwarders based on filtered environmental indicators could also enhance their performance and level of importance. One of these study’s methodology design limitations is the adoption of Mangold Fauld’s social media categorization. With the current advancement in social media platforms, future studies may consider modifying the categories of social media microblogs while exploring social media utilization in CSA tools. The results and discussion of the content analysis review are presented in the next section.

3.5 Results and Discussion

3.5.1 Description of the Explored CSA Tools

Table 3.1 shows the selected CSA tools with the version's specification for the study's content analysis. While the recently examined tool was revised in 2019, the earliest was developed in 2006, meaning all the selected CSA tools were designed after the social media boom in early 2000 (Bodnar, 2020). The tools originated and were utilized mainly from the developed world, such as Northern America, Sweden, Austria, Netherland, and Japan, except for South Africa, Indonesia, Saudi Arabia, and Chile from the developing countries. These utilization locations show that most of the tools are conceived in places where social media platforms for communication and citizen participation are well-grounded. The tool with no specific place of origin was formulated by the Association of University Leaders for a Sustainable Futures (ULSF) with its headquarters in the United States of America (also a developed country with broad social media usage).

Table 3. 1: Selected Campus Sustainability Appraisal Tools

CSA Tools	Version Explored	Document Type	Originated
GASU	2006	Article	United Kingdom
SUM	2006	Article	Mexico
UEMS	2008	Article	Saudi Arabia
SAQ	2009	Report	United States
AISHE 2.0	2009	Manual	Netherland, Austria, Sweden, & Spain
USAT	2009	Report	South Africa & Sweden
TUR	2010	Article	Slovenia
D-SiM	2011	Article	Canada
Graz	2013	Article	Germany
SCAS	2013	Report	Japan
AMAS	2015	Article	Chile

Green Metric	2019	Report	Indonesia
STARS	2019	Technical Manual	North America

The content analysis also reveals that the tools were developed by (i) scholar(s), industry practitioners, or group of academicians' (ii) scholar(s) and industry practitioners in collaboration with foundations, governmental or non-governmental organizations, and (iii) institutions or companies. This description is interesting as some of the later versions of some of the tools were developed by international organizations that spread across different developed countries where social media use is rampant.

The extensive content analysis of these tools' documents shows that SUM is driven by General Systems Theory and Continuous Improvement Philosophy (Velazquez et al., 2006). SUM also adopted a management philosophy known as the Plan-Do-Check-Act (PDCA) cycle to ensure a continuous improvement of campus sustainability initiatives. The General Systems Theory was used in SUM to lay out the critical component for comprehending factors within the framework of a dynamic system. On the other hand, AISHE 2.0 was driven by a European Foundation for Quality Management (EFQM) model. While Linkage-based Frameworks drove D-SiM, the Green Metric was driven by E's: Environment, Economics, Equity, and Education. The remaining are motivated by identified drawbacks of the previous CSA tools and sustainability performance challenges of HEIs within their geographical space without serious consideration for tested theoretical basis or frameworks that could conceptualize social media data utilization. The content analysis also reveals that the tools seem to concentrate on ranking and rate the sustainability performance of HEIs based on data availability rather than from massive data sources from different social media platforms with a social theory that could serve as a foundation for the appraisal process. None of them used main social theories that would have guided their methodology in applying social media data, notwithstanding the expansion and advancement in social media at the establishment phase of most of these tools.

Based on the findings of (i) experiences in life and (ii) social interaction being the most critical factor for the generation of the UGC by online users (Bing Pan, Tanya Maclaurin, 2007); the adoption of a social theory based on the identification of symbols used in human socialization and challenges within human societies is paramount in understanding the symbols online users have on environmental campus-wide sustainability in HEIs. These symbols will allow for the establishment of appraisal tools that will focus on appraisal exercises with a specific focus on campuses' needs and wants within the same geographical locations or with familiar symbols.

3.5.2 Environmental-dimension Attributes and Utilized Social Media Platforms

One of the paramount principles of indicator selection during the development of a sustainability framework is incorporating relevant stakeholders (Hezri, 2004). However, studies show that the data availability shortcomings of these sustainability indicators, decisions on priorities of selected indicators, and CSA outcomes can be easily resolved if prepared to incorporate views from international and local communities. A focus on local and or international public participation while setting up CSA indicators, resulting in locally or internationally defined indicators that differ from general indicators for statistical information, is essential. This public participation helps eliminate the challenges of stoppage, suspension, and postponement of HEIs environmental sustainability-based infrastructural design, planning, and operations. While some of the reviewed tools placed special attention on the indicators selection process and the data collection process for empirical validation, other tools are developed to improve the process of indicators selection. Data sources for data collection, data collection for validation, and case studies for empirical justification were extensively studied during the study's content analysis stage. **Table 3.2** shows the selected indicators sources and the social media platforms that were utilized either during the selection/evaluation stage or for HEIs sustainability rating/ranking purposes. In identifying the social media types or platforms used, the study adopted Mangold and Faulds' social media categorization (Mangold & Faulds, 2009).

Table 3. 2: Selected Tools with Social Media and Environmental-dimension Attributes

CSA Tools	Environmental Attributes	Indicator Source	Social Media Types
GASU	7	Existing tool & workshop	-
SUM	10	Literature review & survey	-
UEMS	12	-	-
SAQ	-	-	-
AISHE 2.0	2	Existing Model	-
USAT	1	Existing tools	-
TUR	-	Existing tools, the Internet, etc.	Wikipedia
D-SiM	27	HEIs with sustainability initiatives	-
Graz	-	Development process	Facebook
SCAS	21	Existing tools	-
AMAS	6	Existing tools	-
Green Metric	11	HEIs concerned with sustainability	-
STARS	18	Multiple sources	Facebook, Twitter, Interactive blog

The findings reveal that only three tools (i.e., TUR, Graz, and STARS) utilized social media. Although the overall result was a bit unexpected, the social media type identified in those tools was expected. This social media type is because there are currently 1.86 billion social media users with an active Facebook account (Misirlis & Vlachopoulou, 2018). On Twitter's social media platform, more than 300 million registered users actively release an average of 500 million UGC across the continent of the world every day (Hasnat et al., 2019). An interesting fact is that although there are campus sustainability indicators in the selected tools for appraising the various HEIs' public participation and involvement of students, the utilization of various platforms of social media for advancing such endeavors was missing. Instead, the traditional face-to-face and physical visitation to the HEIs are still in use by some of the tools such as AISHE 2.0. Also, the use of the internet that involves google search engine, university webpage, email, webometrics, etc. was identified as the information communication technology (ICT) adopted in communicating with stakeholders, experts, practitioners, etc. in the process of data/indicator collection in majority of the tools without social media utilization.

Although this review only focuses on indicator-based sustainability appraisal tools within HEIs, the overall result is contrary to the current advancement of HEIs campuses' practices due to social media emergence (Zachos & Anagnostopoulos, 2018). A vast amount of relevant and measurable data (social data) can be utilized to monitor campus-wide and environmental-dimension sustainability indicators and analyze sustainable behaviors produced on social media. As such, making these data useful for environmental-based sustainability appraisal. The continuous monitoring and review of campus blogs could also be cost-effective compared to the current approach that only relies on tools designed without public participation. With detailed knowledge of behavioral patterns regarding environmental sustainability habits or initiatives on campus, CSA tools developers may use the extracted social media information to enhance their frameworks. Social media analysis is a collection of processes involving collecting, monitoring, measurement, calculation, evaluation, interpretation, and reporting (Kaplan & Haenlein, 2010) of social media UGC.

Moreover, the selected 13 analyzed CSA tools' content analysis revealed that 50 indicators with 65 sub-indicators spread across 13 environmental-related categories. The remaining indicators and sub-indicators fall underneath other categories, such as socio-cultural, institutional, and economic, that are not in line with this research's scope. From the three extant tools with social media platforms (see **Table 3.2**), Graz contains neither indicators nor sub-indicators with environmental-dimension. On the other hand, TUR only has one category named "environmental" without indicators and sub-indicators with environmental-dimension. STARS, which was conceived and developed by the Association for the Advancement of Sustainability in Higher education (AASHE) in collaboration with various HEIs in North America in 2006, has six indicators and 12 sub-indicators under one category that are environmental in dimension. This finding shows that only one tool (i.e., STARS) with environmental-dimension attributes utilized social media platforms from the extant tools. To contextualize the universe of HEIs registered to utilize STARS for sustainability assessment, the number of HEIs, countries, and the geographic region from the official website of STARS was obtained.

Table 3. 3: STARS' Participants with their geographical regions (The Association for the Advancement of Sustainability in Higher Education, 2020)

Geographical Regions	**Countries**	**Higher Education Institutions**	**Sustainability Rating**
Africa	Morocco	1	Silver
	Egypt	1	-
	Nigeria	1	-
America	United States	821	Platinum, Gold, Silver, Bronze, Reporter
	Canada	90	Platinum, Gold, Silver, Bronze, Reporter
	Colombia	1	Reporter
	Ecuador	3	Silver
	Costa Rica	1	-
	Bahamas	1	-
	Chile	3	-
	Venezuela	1	-
	Nicaragua	1	-
	Panama	1	-
	Mexico	29	Gold, Silver
	Brazil	3	-
Asia	United Arab Emirates	2	Bronze
	Japan	3	Reporter
	Pakistan	2	Reporter

	Kyrgyzstan	1	-
	Philippines	2	-
	India	2	-
	Malaysia	1	-
	Iran	1	-
	Saudi Arabia	2	-
	Taiwan	2	-
	Singapore	1	-
Europe	Greece	2	Gold
	Ireland	2	Gold
	Portugal	2	Bronze
	France	1	Reporter
	Switzerland	2	Reporter
	Netherlands	6	Reporter
	Denmark	2	-
	Russia	1	-
	Spain	3	-
	United Kingdom	4	Silver
	Italy	1	-
	Turkey	2	-
	Hungary	1	-
	Germany	1	-
Oceania	Australia	6	Silver
	New Zealand	3	-

In **Table 3.3**, the world's region with the least participating HEIs is considered to be needing future considerations, although the geographical regions with HEIs with moderate to high participation rates also demand a future inquiry. Based on the content of **Table 3.3**, the world's region with campus-wide environmental challenges where social media platforms and UGC have not been extensively utilized in the STARS tool is mainly the Africa continent, with only three HEIs. Based on the United Nations geoscheme for Africa, two HEIs from Northern Africa are registered participants. At the same time, only one university in Nigeria from the whole of sub-Saharan Africa is a registered participant. The website search also reveals that this higher institution in sub-Saharan Africa registered to utilize the STARS framework with neither a sustainability rating nor reports of campus-wide sustainability performance measurement. This finding is in contrast with HEIs in Northern Africa with sustainability ratings.

This outcome shows that there is an opportunity for including the utilization of social media that extract contributions of various stakeholders in (i) designing appraisal frameworks, models, and or tools, and (ii) advancing decision making and determination of relative importance for environmental-related sustainability indicators peculiar to the HEIs in this region. Although STARS is the only tool with an environmental-indicator-based tool for HEIs campus sustainability appraisal with social media platforms, it is by far not a perfect model for campus-wide environmental sustainability appraisal of HEIs in sub-Sahara Africa. In the STARS technical manual, points are allocated to HEIs that advance sustainability teaching, research, and knowledge via social media platforms that concentrate solely on campus sustainability. How the social media UGC are utilized to apprise campus-wide sustainability performance or preferences of environmental-sustainability indicators are missing. Sonetti and colleagues highlighted STARS' weaknesses as giving the same weight to each category and treating each HEIs as the same (Sonetti et al., 2016). This sustainability rating of all HEIs across the globe based on a similar appraisal is contrary to the tenets of several international organizations such as the World Green Building Council that stipulate sustainable green campus implementation based on individual countries' local and regional environments.

3.5.3 Integrating Social Media UGC into Environmental CSA

In the sub-sections above, the content analysis of the 13 analyzed CSA tools reveals the limited usage of social media UGC and platforms in the appraisal process of sustainability practices and performance of HEIs and, as such, the need for more utilization and incorporation in future studies and or CSA tools/framework development. Regarding ecological and environmental sustainability in sub-Saharan African HEIs, social media utilization and public participation in decision-making are still lagging (see **Table 3.3**). Although USAT was designed to implement sustainability performance appraisal in a joint training program between African and a European country (Togo & Lotz-Sisitka, 2009), social media was neither utilized to identify the tool's selected indicator nor the empirical validation of the tool. This is despite the absence of most HEIs in Africa as signatories to the Talloires Declaration and the insufficient inclusion of sustainability initiatives in the vision and mission of most of the HEIs in Africa. This insufficient campus sustainability signatory participation and vision statements are some of the justifications for adopting or developing a framework that will incorporate various social media platforms to allocate relative importance and weights to selected environmental-dimension indicators for CSA in advancing campus planning sustainability in African institutions. More so, the Abuja declaration for sustainability in Africa HEIs recommends the appraisal of campus practices and operations to ensure the sustainability perpetuity of the campuses of HEIs in the continent (AAU, 2009).

CSA tools' developers and or scholars interested in filling the identified research gaps in this study could advance on the tools designed by Togo & Lotz-Sisitka, (2009) to develop a model to assist in resolving these HEIs sustainability challenges in sub-Saharan African nations. The establishment of such a model should also concentrate on incorporating and appraising ecological and environmental dimensions with spatial-temporal indicators that ensure not only campus higher QOL, livability, performance, and practices but also thematic results that could be easily interpreted by a more massive member of the relevant HEIs stakeholders. Thematic display and results visualization are essential for increasing easy comprehension and eliminating complex technicalities for the larger audience.

Besides, future social media utilization could concentrate on designing a campus-wide sustainability appraisal model for HEIs in sub-Saharan African nations where access to data for the assessment process is difficult to obtain, and the situation of campus-wide sustainability results are unknown/unreported. Gomez and colleagues stated their Adaptable Model for appraising sustainability in HEIs was designed for nations at the fledgling stage of sustainable development peculiar to South American countries (Gomez et al., 2015). As such, the need to develop an adaptable framework integrating social media UGC into CSA in countries in sub-Sahara Africa, where the status of environmental sustainability performance and practices in their HEIs is obscure. With Nigeria being the only country with a registered university to utilized STARS for sustainability appraisal but without any reports to show the use of social media, the proposed framework could be tailored for HEIs in Nigeria and, by extension, to other sub-Sahara African countries. The Nigerian institution's inability to appraise its campus-wide sustainability performance might be due to the substantial financial cost required by HEIs to participate and become a registered member before utilizing the STARS rating tool. With the proposed framework, the financial cost and time consumption will be eliminated due to its uncomplicated nature and the use of free, open-source software. In the next section, an approach that could be adopted or modified for appraising HEIs environmental sustainability indicators preferences within the context of sub-Sahara Africa was discussed.

3.6 The Proposed Framework for appraising the Preferences of Environmental Sustainability Attributes based on Social Media UGC

Although many scholars have criticized UGC's utilization, adoption, and trustworthiness on social media (Sparks & Browning, 2011; Yoo & Gretzel, 2011), primarily due to the anonymity of their sources in some social networking sites, however, most of this criticism has been disproved (Burgess et al., 2009). The UGC is adaptable and reliable because they represent the actual involvement, experience, and reality of the people and not the opinion of selected experts (Sun et al., 2018). In fact, social media users providing the UGC are not losing anything by making comments, views, and personal experiences (Burgess et al., 2009), justifying the integrity and genuineness of social media UGC compared to existing data sources (Akehurst, 2009). Social media UGC can reveal an unparalleled recent and variety of campus-wide environmental-dimension sustainability information to HEIs stakeholders. It is also relevant for appraisal tools developers before and during (evaluating alternatives and selecting sustainability indicators) the framework and data collection stage. Despite the few usages of social media platforms among the analyzed tools, the content analysis reveals the inclusion of communication and related indicators in appraising the sustainability performance of HEIs.

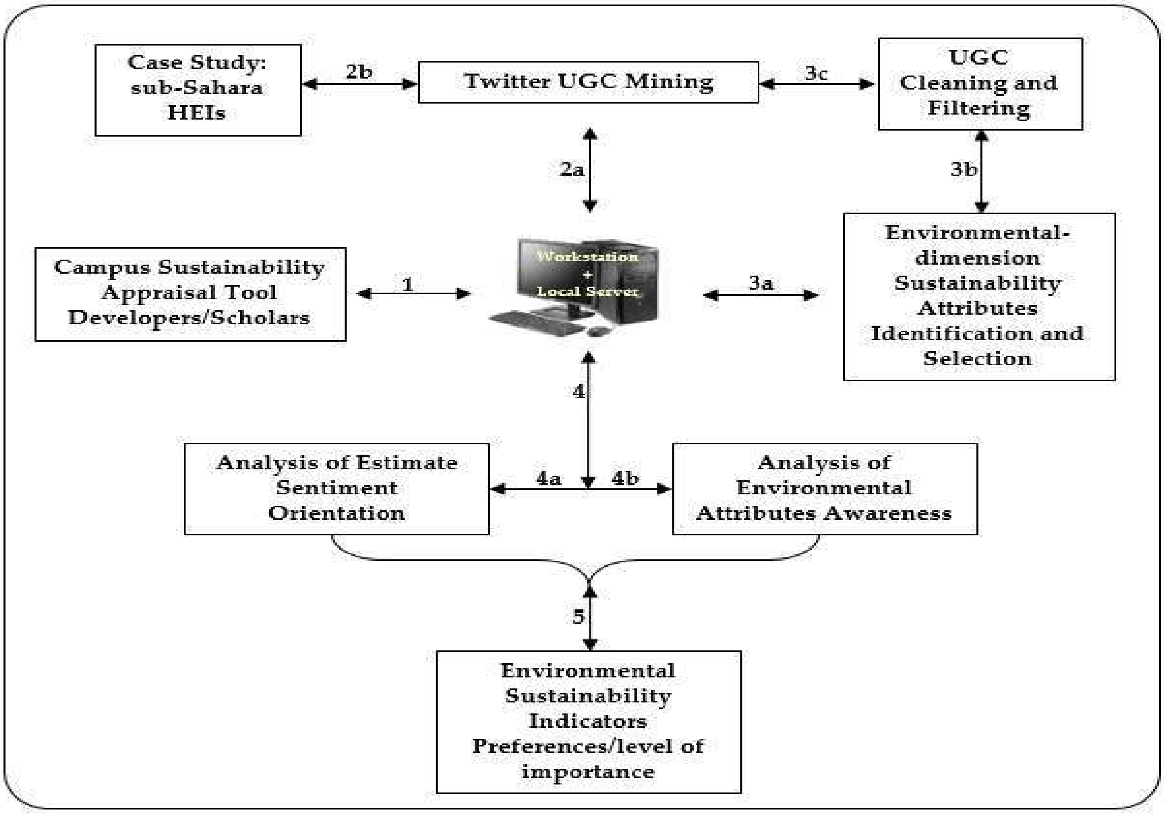


Figure 3. 2: A Framework linking social media to CSA

Figure 3.2 depicts the study's proposed approach linking Twitter social media UGC to environmental-dimension indicators preferences for campus-wide sustainability appraisal for HEIs in sub-Saharan African nations. This approach is based on the comprehensive studies of the existing CSA tools, social media platforms, social media/big data mining tools, sentiment analysis software, and social theories with social interaction tenets.

3.6.1 Environmental Sustainability Indicators Preferences Towards Sustainable Campus

Preferences of environmental sustainability indicators can be referred to as public perception and views on different campuses' sustainability practices, either positive or negative, and sometimes neutral. It can also be regarded as experts' feedback on the level of importance of some indicators, attributes, campus resources, conditions, and management based on experience and expertise. Their preference can reflect how different campuses attract students, investors, sponsors, funding, and grants and can also place the campuses to attain higher environmental sustainability assessment rankings and ratings. Besides, preference serves as an essential attribute when designing an assessment model or tool that reflects the end-users demand and aspirations.

These preferences can be determined via the level of stakeholder satisfaction with sustainability practices on campus and stakeholders' awareness toward sustainable campus and other related topics. The need to assess these preferences results from the fact that it is highly essential to ensure that HEIs stakeholders' satisfaction and awareness align with campus setting and infrastructure, transportation, operations, management, etc. Currently, a larger percentage of studies and research that measure and assess the HEIs stakeholders adopt methods like an expert opinion, small group interviews, questionnaire surveys, expert scoring, analytic hierarchy process (AHP), fuzzy TOPSIS, and important performance analysis (IPA). These data collection methods are usually carried out with a few paramount stakeholders in tertiary education institutions and campus planning and development. For example, in 2015, a study measured experts' preference on a set of 35 importance-performance attributes by applying the AHP for a sustainable campus appraisal in Andalas University (Amrina & Imansuri, 2015). Also, fuzzy TOPSIS was utilized in another study to obtain experts' preference from Egypt and Canada on seven sustainability criteria when designing a sustainability assessment model for existing buildings in universities (Mahmoud et al., 2019).

This study does not condemn or undermine the research outcomes of the aforementioned methods that have been mostly used in conducting stakeholders' or expert preferences in sustainable campuses.

However, these methods' objectivity when considering all the factors involved in arriving at the stakeholders' preference is not convincing enough, mainly due to the database's limitation or the number of stakeholders involved before arriving at the final preference. As of January 2019, the number of global active social media users was around 3.5 billion, while those active on mobile are around 2.3 billion (Hasnat et al., 2019). With this trend, it will be wise to incorporate social media data analysis precision and accuracy. The utilization of the enormous volume of UGC from different social media channels to monitor the trend of sustainable campuses in sub-Saharan Africa will close a huge research gap in this field.

3.6.2 The Description of the Proposed Framework

This proposed framework is structured to allow for flexibility and modification of use by interested users or HEIs across the region. The proposed framework's description is provided in this sub-section based on the procedure numbering in **Figure 3.2**.

Firstly, the CSA tool developers, scholars, or technicians with designated workstations and high-performing computer systems connected to the internet or local server. The computer system should be installed with Python 3 software if not already pre-installed. For beginners, the official website[4] contains the procedures to download and install the software.

Secondly, Twitter, Inc.'s social media platform allows scholars or CSA developers working on social media UGC for environmental sustainability indicators appraisal to access its social networking and microblogging data. Data sources of multiple categories can be retrieved from the Twitter API via the utilization of scrapping tools (i.e., Octoparse, Visual Web Ripper, Content Grabber, etc.) specifically designed for performing online data mining (Khan, 2013). A limited amount of social networking data such as users' UGC, profile, and entities provided by different Twitter registered users in different parts of the world can be mined by the CSA developers, scholars, or technicians through the Twitter API into

[4] https://wiki.python.org/moin/BeginnersGuide/Download

different preferred storage devices on the computer system at the designated workstations. Depending on the UGC volume, it could be stored in a SaaS storage platform, external storage devices, an internet development environment, or an Excel sheet. Although "big data" is referred to by a scholar as data that could not be stored in a Microsoft Excel spreadsheet (Batty, 2013). For CSA studies, UGC that is huge enough for advancing campus-wide environmental sustainability indicator preferences appraisal based proposed framework is acceptable since the goal is on social media UGC utilization and not big data definition of some selected scholars. With Twitter API, the UGC mining process could mainly be achieved after the scholars interested in this data set have successfully applied and granted a Twitter developer account. The scholars and developers can conveniently and efficiently utilize an online information processing tool known as Logstash (Bajer, 2017). Logstash can be downloaded and installed[5] freely to scrap and transform Twitter UGC from HEIs Twitter APIs in sub-Saharan African countries in unstructured format to easy to process file format. Due to the insufficient and restrictive nature of UGC via the APIs of the Twitter social media platform, {2a} Python Library: GetOldTweets[6] is proposed for mining unlimited UGC in the file format of a CSV. The command-line utility and specific or combinations of examples/use cases that could be utilized for mining UGC from {2b} UGC from Twitter accounts of any HEIs within sub-Sahara Africa or any part of the world can be modify via the command line utility contained in the attached link.

Thirdly, after the completion of {2a} Twitter UGC mining from {2b} case studies within sub-Sahara HEIs, the CSA tool developers or the scholars need to recognize that although the procedure for choosing a set of CSA indicators is conducted objectively, the selection will always reflect value judgment about what indicators are more useful than others. Therefore, {3a} when identifying and selecting indicators, it is essential to maintain transparency when possible and carry out the process in a participatory manner. Good campus sustainability indicators have to characterize the environment concisely they intend to depict (Cole, 2003). Therefore, it is imperative to take into account all possible

[5] https://www.elastic.co/guide/en/logstash/current/installing-logstash.html
[6] https://pypi.org/project/GetOldTweets3/

aspects of campus-wide and environmental-based indicators. The content analysis of the 13 analyzed CSA tools shows the presence of environmental-related sustainability indicators. In addition to identifying and selecting these indicators from the existing tools, these sustainability attributes could also be retrieved from paramount representatives of the HEIs via social media platforms. In ensuring that the identified sustainability indicators meet the specific institutions' requirements within the sub-Saharan African nations, the SMART approach guarantees that the selected indicators are specific, measurable, achievable, relevant to the local context, and time-bound is also proposed. Once the environmental-dimension sustainability indicators are selected based on the SMART approach, {3b} the UGC cleaning, analysis, and filtering process would be carried out to identify the selected environmental indicators from the {3c} overall volume. This phase will involve feeding the mined UGC from either a SaaS storage platform, external storage devices, an internet development environment via Logstash into Elasticsearch for the cleaning (removing repeated UGC, etc.). Elasticsearch is an open-source[7] storage and fast analytic tool. When confronted with the challenge of comma separations and the irregular arrangement of data in CSV, which makes data analysis very difficult to achieve in the Elasticsearch environment, Python programming language could be introduced to transform the data from CSV to JSON or nlJSON format. For the visualization of the extracted clean UGC stored in Elasticsearch, Kibana, another open-source[8] software, should be installed to filter and select only UGC containing the selected {3a} environmental sustainability indicators. The UGC with hashtags (i.e., #symbols at the beginning of each word) could be piped into Gephi software to create a connection of nodes with interrelated edges. After that, Eigenvector Centrality, Average Degree, and Modularity could be utilized in appraising the effects of hashtags on the interconnected nodes.

Fourthly, social media applications are perceived as platforms where individuals communicate to make reviews and their sentiments on their purchased goods or services rendered in the marketing field (Larsson, 2010). In return, the suppliers of these goods or services will utilize their customers'

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[7] https://www.elastic.co/downloads/elasticsearch
[8] https://www.elastic.co/downloads/kibana?S_TACT=

sentiments to improve their services' products or quality. Likewise, social media online users also communicate their sentiments and review regarding campus experiences and their challenges regarding environmental-related issues. As such, CSA tool developers or researchers need to exploit the potentiality of this social media UGC for environmental sustainability preferences. With the adoption of machine learning, artificial intelligence involving sentiment analysis {4a} based on the selected indicators, the indicators' positive and negative orientation could be established. Manual sentiment analysis can be performed when the volume of the mined UGC is minute. Therefore, free to use Azure Machine Learning was proposed to analyze every selected environmental sustainability indicator in gauging sentiments, attitudes evaluations, and HEIs stakeholders' emotions within the selected case studies. With the extractions of insights from the UGC, appropriate measures and policies relating to each environmental indicator would be effectively and efficiently addressed. Also, {4b} to the campus sustainability indicators embedded in the sum up UGC with a higher number of favorites, replies, and retweets will be given higher preferences than those with lower figures. After that, further analysis of surveys and interviews from experts in data science or urban planning could be carried out to validate the weights of the social media favorites, replies, and retweets.

Finally, with the sentiment and awareness analysis results, {5} the outcomes of environmental sustainability indicators preferences or level of importance could be obtained.

In summary, this is the first attempt to integrate social media data in appraising sustainability indicator preferences to minimize the identified research gaps. The proposed framework can foster a novel systematic approach for conducting CSA, primarily due to the difficulties of obtaining information relating to environmental sustainability indicators in sub-Saharan African nations. However, it must be kept in mind that all frameworks have certain kinds of limitations in their assessment regime, and this framework will be no exception. One limitation is the computer skills required to build the system in addition to workforce skill training. The accuracy of data entry and manipulation can also affect the outcome. However, the framework is flexible, and future research using the proposed framework can modify the approach.

3.7 Conclusions

The links to at least one social media platform were observed on some selected websites in HEIs in Asia and sub-Saharan African nations. However, the review of existing CSA tools reveals the limited coverage of social media in developing and selecting sustainability indicators. These outcomes show scholars and appraisal tool developers' insensitivity in utilizing and incorporating social media's innovation, convenience, and advancement. This study's contribution to knowledge is answering what has developers and scholars of CSA tools implemented concerning social media data. This article seeks to assist CSA experts and tertiary institution scholars in having a more appropriate insight and knowledge of social media data utilization in the framework of sustainable appraisal of HEIs. It theoretically contributes to CSA studies based on recognizing the research gap, followed by an approach to filling the identified void.

This research's findings, discussions, and implications are also relevant to scholars and experts with research interests in big data, social media, artificial intelligence, and ITC. One of the implications of the social media data incorporation in CSA is the inclusion of rumors or negative comments online users provide. However, this is perceived as a chance to advance the appraisal process as the comments could be easily treated, addressed, or classified as outliers. With the incorporation of sentiment analysis/artificial intelligence, a considerable volume of social media data could be analyzed to understand the perception of sustainability in HEIs based on social media users' information. Negative comments signify the need to improve sustainability performance relating to the affected environmental sustainability indicators.

In campus design, development, and planning, as the project's execution mostly demands teamwork, participation, and communication among consortiums, the utilization of social media can effectively communicate and gather information for both present and future sustainable approaches and methodologies. The social media platform UGC has the potential of deriving enhanced and insightful information on aspects of HEIs sustainability that deserve attention. Although some social media platforms' playful nature might hinder an effective collaboration, it was discovered that they provide a fascinating avenue for sharing and discussing different materials like sustainability courses and significant mutual contributions between students and teachers (Isacsson & Gretzel, 2011).

3.8 Chapter Summary

As one of the buzzwords in the present age with considerable impacts in tertiary institutions, social media use in online teaching, learning, and information dissemination has been extensively discussed in extant literature. This chapter explores the existing campus sustainability appraisal tools to identify the length at which social media has been utilized, especially in environmental sustainability indicators selection and empirical verification. The tools' content analysis reveals the insufficient utilization of social media data and platforms in campus sustainability environmental-dimension indicators selection. In bridging the identified research gap, an approach to utilizing social media user-generated content in appraising the campus-wide sustainability performance of tertiary institutions was proposed. The adoption and or modification of this approach by tertiary institutions, especially in sub-Saharan African countries, could help address most campus ecological challenges that have been raised, commented on, and discussed on social media. With the expanding utilization of different social media platforms by various tertiary institutions worldwide, their administrators' responsibility is to put these social media data into fair use.

CHAPTER 4: TOWARDS THE ADOPTION OF SYMBOLIC INTERACTION AS A THEORETICAL BASIS FOR CSA[9]

4.1 Chapter Overview

Adopting a theoretical basis in explaining campus-wide and environmental sustainability issues is one of the challenges currently confronting campus planners, scholars, and assessment developers. Main social theories with clear interpretation are paramount in substantiating spatial-related sustainability issues within HEIs. Every scholar must ensure the formulation or adoption of theories since theory development is part of the fundamentals of environmental sciences. Methods selection is not enough without theoretical perspectives behind the adopted methods. A theoretical perspective is key in categorizing, structuring, and interpreting methodological research findings if CSA is to be advanced.

The purpose of this chapter is the selection of a well-grounded social science theory that will serve as a theoretical perspective for the development of a CSA framework for HEIs in Nigeria. An in-depth review of the notable strands and philosophical perspectives of five leading social theories was presented in this chapter. The review outcomes present the differences in the theories' perspectives, how their selection will influence the study's research outcomes, and their pros and cons. The theoretical significance of the selected social theory in building a spatial-based sustainability appraisal framework for HEIs in Nigeria is also discussed. A pilot study within a university in Nigeria was also carried out to test-run the adopted theory incorporation with the proposed framework.

The main social theories selected for review are (i) Marxism, (ii) Functionalism, (iii) Anthropocene, (iv) symbolic interaction, and (v) interactionist theories. These five theories were selected because of their focus on society, socialization, human interaction with their external world from both positive and negative outlooks. In Chapter 3, an absence of a social science theory driving social media in existing tools was identified. In this chapter, the framework for the selected theory was presented. A

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comprehensive review of 13 exiting CSA tools was also carried out to identify the theories that have been previously used in appraising HEI's sustainability performance. The criticism and the general limitations of the adopted theory were also presented.

4.2 Introduction

There has been massive contention in the literature on the applicability and adoption of qualitative and quantitative research methods in urban and regional planning disciplines (Dong et al., 2019; Kaufmann, 2016). This contention has created what can be referred to as an artificial boundary among the scholars of urban planning and campus design, even though both methods contribute different leverage to advancing theories and development in the field. These scholars are not supposed to be concentrating on the right or wrong method. Neither are they supposed to be creating boundaries between these methods since one of the field's objectives is developing theories. Merging the two methods when solving campus neighborhoods' challenges can increase our understanding of humans' behaviors and preferences toward campus design and appraisal for sustainability and reduce each method's limitations.

Several studies have provided various pragmatic approaches to combining qualitative and quantitative methods when conducting urban planning research (Hewlett & Brown, 2018; Yu, 2018). Irrespective of qualitative or quantitative, any study's core should be a theory as significant guidance for the research process. The discussion of a phenomenon with the omission of a theory could be referred to as talking about things that cannot be regarded as a well-grounded study. Although, several challenges such as differentiating or merging the philosophical approaches or various assumptions of different theories are still being experienced. Identifying and rectifying diverse theoretical bases during the process of conducting sustainability performance appraisal of HEIs campuses is essential, especially for scholars utilizing the triangulation research approach. In ensuring the advancement of campus planning and development in a scholarly manner, there is the need for a theoretical basis/framework for the structuring and interpreting index and management of campus sustainability indicators from the perspective of quantitative and qualitative methodology.

Due to the diverse nature of most campuses of HEIs and the complex process involved in sustainability assessment for QOL, several challenges of appraising sustainability performance (Dijk et al., 2017; López & Sánchez, 2011) and especially within HEIs have been recorded. The utilization of an appraisal tool for monitoring and evaluating the level of sustainability accomplishment and, most notably, a theoretical foundation for explaining the overall or parts of the appraisal process could overcome these challenges. Within the built environment and social sciences disciplines, theoretical perspective studies are undoubtedly significant components. Several scholars of repute within the disciplines have conducted their studies based on either adopting a theoretical basis or proponents of specific theories. However, recently, studies and scholars without theoretical basis, theoretical development, theoretical adoption, theoretical school of thought have become dominant, and preferences for only experimental and quantitative research methods have become the order of the day. Some of the cons of this recent trend, especially in CSA endeavors, including but are not limited to lack of appropriate framework/methodology, inability to interpret and discuss campus issues with persistent philosophical guidance, and difficulties in differentiating various campus events.

A review of extant literature reveals that the majority of campus planning researchers tend to approach the studies relating to sustainability appraisal on HEIs campus based on the AHP (Lukman et al., 2010), expert scoring, survey, fuzzy TOPSIS (Mahmoud et al., 2019), etc. without a theoretical basis or the utilization of HEIs relevant stakeholders information available on social media platforms. The rise in studies, articles, and interest in campus sustainability reporting, auditing, tracking, assessment, certification, etc. within the last few years warrant for the review of existing CSA tools to identify theories utilized in driving their framework development, identification, and selection of sustainability attributes, and sustainability appraisal process. The identification of these utilized theories/theoretical basis within these existing tools in guiding their efficient development, innovative approach of implementing and interpreting appraisal outcome is paramount for campus planners, scholars, policymakers, administrators, and politicians involved in campus planning, administration, designing, and development most significantly in developing countries with the absence of country specific-appropriate model and sustainability performance record.

4.3 Background and Justification for Theoretical Basis/Framework

The trend and focus of professionals in the built environment such as Architects, Builders, Civil and Structural Engineers, and most importantly, the Urban Planners have been on sustainability design, performance, and practices within the campuses of HEIs in recent years. There are several studies, research, and projects that indicate the link that exists between the HEIs campuses sustainability quality, performance, wellbeing, and most importantly, the health of students, staff, and non-teaching staff in different parts of the world (Alshuwaikhat & Abubakar, 2008; Sonetti et al., 2016; Velazquez et al., 2006). Some of these professionals' justification for conducting and implementing sustainability initiatives at the HEIs level is to ensure that sustainability principles are enshrined on the students during their stay on the campuses. While some perceived it as an avenue to improving the performance and management of the facilities and infrastructure owned and operated by the HEIs, others perceived it as a positive solution to implementing sustainable community service.

The existing studies show that it is essential to ensure that the environment of HEIs is healthy because some of the toxics and pollutant-causing health challenges are prevalent on campuses. Others reveal the low motivation and productivity among students and staff, the high rate of absenteeism, and the rise in respiratory diseases due to low indoor environmental quality within some of these campuses' offices and classrooms. Several other studies have been conducted that show the correlation between the students' well-being, performance, health, and campus environment quality (Taylor et al., 2019).

Many studies in extant literature also show the impacts of lighting and air quality on students within the school campus. The study conducted by Mahone (2003) to demonstrate the relationship that exists between indoor environment and the academic performance of students shows that students in campuses with better daylighting and environment with the quality environment have test scores that are higher when compared to those students in classrooms with no assess to daylighting. Mendell and Heath, (2005) research findings show low performance and a high absenteeism rate among students with a poor indoor environment and low ventilation rate compared with their counterparts with a high ventilation rate and air circulation rate. Also, the International WELL Building Institute (2017) states that there is a strong link between an indoor environment daylighting and the circadian rhythm that seeks to improve the performance, health, and the reduction in stress among the students and staff within school campus premises. Research also found that young HEIs students have a higher rate of experiencing short and long-term health-related diseases such as asthma and rhinitis when exposed to poor indoor air quality compared to aged students due to their young and fragile organs.

Still, several studies have shown that campuses' thermal comfort affects students’ performance and general well-being. The study conducted by Wargocki & Wyon (2007) confirms that there is a significant negative impact on students’ performance when their classrooms' temperature increases compared to a classroom with a moderate temperature. Other research has also shown that campuses that are designed and planned to encourage sufficient space for physical activities improve cognitive performance and the students’ physical and mental well-being.

In addressing the challenges highlighted above, HEIs in different parts of the world, within the last few years, have been aiming to ensure their campuses are environmentally friendly with a series of sustainability policies, projects, course works, and plans. A higher percentage of these sustainability initiatives within various campuses are due to the numerous vital roles that HEIs have played in places like the USA and the United Kingdom (Elder, 2008). Aspects of HEIs campuses such as operations, development, and research are also currently undergoing modification that entails introducing sustainability concepts in different parts of the world. This restructuring is necessary and inevitable because of the various negative impacts of the developmental activities and operations within HEIs campuses on the environment and ensuring that the students within these institutions embrace a sustainability mindset and culture during their stay on campus. In the developed countries, sustainability appraisal initiatives have been proposed for implementation, and a reasonable amount of institutions have carried out a sustainability appraisal of their campuses backed with necessary mitigation measures. The signing of different sustainability declarations (i.e., Talloires Declaration and Abuja Declaration on Sustainable Development in Africa) by management or heads of HEIs in addition to demands by stakeholders of these HEIs have increased the implementation of sustainability strategies and programs at multiple institutions across the globe (Cortese, 2003).

Besides, a couple of appraisal tools have been developed specifically for monitoring the sustainability attainment of HEIs (Grindsted, 2011; Grindsted & Holm, 2012; Lozano et al., 2013; Tilbury, 2011; Wright, 2004; TSA Wright, 2002). Several limitations of these tools have been identified, discussed, and documented in extant literature (Alghamdi et al., 2017; Ceulemans et al., 2015; Kamal & Asmuss, 2013; Shriberg, 2002; Sonetti et al., 2016; Yarime & Tanaka, 2012). However, a review of the utilized theory/theoretical basis in the existing tools is missing. As such, the justification for this study. A comprehensive review of the existing tools to identify the explanation and theoretical approach/framework regarding sustainability issues in HEIs is vital at this stage to provide a foundation for CSA and framework development, especially in the global south.

4.3.1 Review of Existing CSA Tools Based on Theory/Framework

In an attempt to identify trends, research gaps, and future direction within a research field, the most used and highly recommended approach is a comprehensive/systematic review and analysis of extant literature. This chapter's systematic review is similar to the approach utilized in Chapter 3, with a few modifications. Therefore, only the research approach and the specific outcomes in terms of theory/framework are briefly discussed in this chapter.

The first stage of a systematic review adopted in this study was an in-depth search for articles specifically published to present CSA tools. This search was carried out on Scopus, which has extensive publication coverage (Bice & Coates, 2016). The search was carried out based on the article title, abstract, and keywords (AAK) of articles from 1972 to 2019. Also, the web pages of all the existing appraisal, rating, ranking, and auditing tools were searched to obtain their manuals and/or reports for review and analysis purposes. The research approach is depicted in **Figure 4.1**.

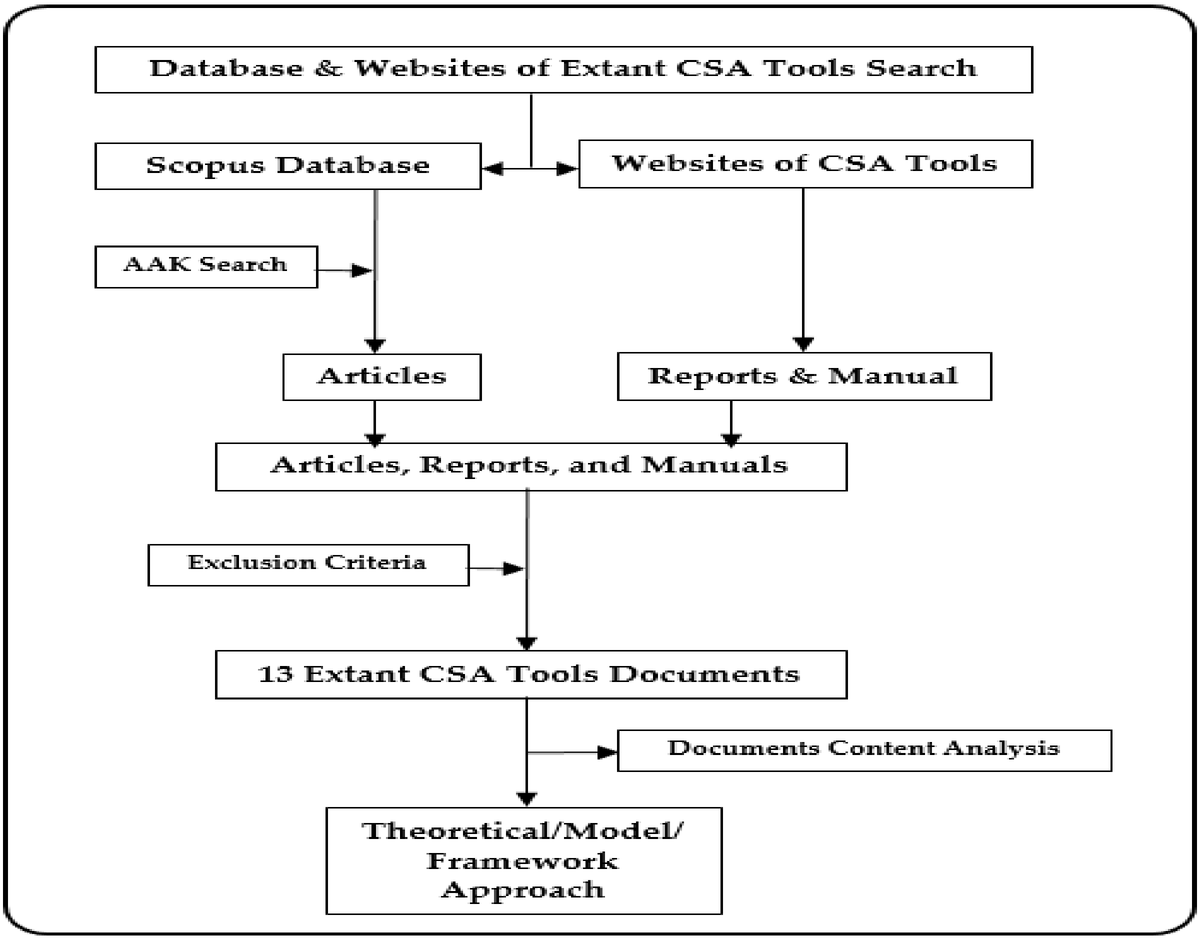

Figure 4. 1: Research Approach for Chapter 4 Research Gap Identification

Although there were many papers relating to campus sustainability, this chapter's focus is limited to documents (articles, manuals, and reports), specifically on CSA tools. At the end of this stage, 13 existing CSA tool documents were selected for further analysis. Like Chapters 2 and 3, their selection criteria are: (a) availability in document format: the CSA tools whose reports or technical manual could not be retrieved from their official website were excluded for further analysis. (b) within the scope of tertiary institution: the tools considered for content analysis are those whose scope is within the context of HEIs campuses. Therefore, appraisal tools developed for utilization within the coverage scope of cities, regions, countries, or public and private institutions were excluded. (c) written in the English

Language: tools whose documents are written in languages that are not English were excluded for further analysis. (d) indicator approach: tools designed based on account or narrative approaches were excluded for further analysis.

After that, the selected existing CSA tools were subjected to content analysis. The review shows that none of the selected appraisal tools used social theories that ensure identification of human behaviors towards selected indicators, continuous review, adjustment, and selection of indicators preferences via the utilization of social media UGC. As shown in **Table 4.1**, the review identified the use of a model (i.e., EFQM (European Foundation for Quality Management) Excellence Model), framework (i.e., link-based framework), and theory (i.e., General Systems Theory). The link-based framework could be in the form of PSR (pressure-state-response), DPSIR (driving force-pressure-state-impact-response) or DPSIR (driving force-pressure-state-expose-effect-action). Specifically, the DPSIR was utilized in the identified tool. The remaining tools were neither driven nor design based on a sound theoretical framework but rather driven by limitations of the existing tools and the availability of sustainability indicators for HEIs. As such, I conducted a review of theories that focus on society, socialization, and human interaction to identify the one that could fill the identified research gaps and serve as a theoretical basis for CSA, especially for countries without any tool/model or record of sustainability appraisal.

Table 4. 1: Comparison of the Selected Appraisal Tools

CSA Tool	**Theory/Framework**
SAQ	-
GASU	-
SUM	(i) General Systems Theory

	(ii) Benchmarking Process (iii) The Plan-Do-Check-Act (PDCA) Cycle
UEMS	-
AISHE 2.0	(i) EFQM Excellence model (ii) The PDCA Cycle
USAT	-
TUR	-
D-SiM	Linkage-based Frameworks
Graz	-
SCAS	-
AMAS	-
Green Metric	Three E's Framework: Environment, Economics, Equity & Education
STARS	-

4.4 Identification of a Theoretical Basis for CSA

Theory development entails formulating and investigating hypotheses or premises, designing these premises into a conceptual framework or theoretical large-scale systematic plan, critically examining and testing the systematic theoretical plan via rigorous statistical analysis of the data or empirical validation. The sub-sections that follow aim to identify adaptable social theories as a theoretical basis for campus appraisal, planning, and design for sustainability due to the gaps identified in the analyzed tools. The systematic/conceptual framework and empirical validation are discussed in the other sections of this chapter. In an attempt to adopt a theoretical basis for CSA, five theories were selected because they focus on society, socialization, human interaction with their external world from both positive and negative outlooks. A brief description of the selected main social theories relating to the societies' structuring and functioning was discussed in the next section. Based on their ability to appraise sustainability in HEIs campus concerning social media UGC, one was selected as a theoretical basis.

4.4.1 Description of the Analyzed Five Main Social Theories

The main social theories selected are (i) Anthropocene, (ii) Functionalism, (iii) Symbolic Interaction, (iv) Interactionist theories, and (v) Marxism. Their description is discussed in sections 4.4.1.1 to 4.4.1.5.

4.4.1.1 The Theory of Anthropocene

Anthropocene is a concept that describes the current millennium as a period dominated by man's activities and is formulated by Eugene Stoermer and Paul Crutzen (Lövbrand et al., 2015). This concept's central claim is that the world is now in a dangerous and unpredictable era where humans are continuously threatening its existence. However, its meaning and importance continue to be disputed and contested. Crutzen and schwagerl (2011) observed that the planet earth is getting Anthropozised at a very high rate and that humans' imprint can be felt worldwide.

While some scholars claimed that the concept placed man at the fulcrum of environmental change at the global level, others perceived it as an idea that emphasized too much dependence on material and natural resources by man (Lövbrand et al., 2015). The proponents of this concept have been claimed by many scholars to be dominated by scholars within the academic discipline of environmental sciences. Vitousek et al. (1997) reported that the discussion on the outcomes and repercussions of human beings' activities like fossil fuel burning, desertification, water wastage were well-grounded among the environmental scientists before the emergence of the word (i.e., Anthropocene) at the beginning of the new millennium. Anthropocene's idea was also linked back to publications written in 1906 by Eduard Seuss, 1945 by Vladimir Vernadsky, and 1874 by George Perkins Marsh (Steffen et al., 2011).

When conducting pragmatic research based on Anthropocene's concept, the researchers' focus is always on the thorough understanding of man's negative impacts on the whole world and ensuring that humans are re-embedded in the planet they are destroying. The whole essence of the Anthropocene is the changing of people's negative behaviors.

Anthropocene's rich concept has gained a wide application in numerous academic disciplines since the beginning of the current millennium (Lövbrand et al., 2015). The Anthropocene's core scientific narrative is the merging together of humans and nature's system (Oldfield et al., 2014). The Anthropocene concept's emergence resulted from the rapid large-scale negative change the planet was beginning to witness due to humans' activities (Zalasiewicz et al., 2010). The significant negative global effect on the planet that gave rise to Anthropocene's emergence is climate change, one of the ultimate challenges this study aims to address. The uncontrolled increase in the concentration of greenhouse gases into the environment partly due to humans' activities within various HEIs campuses across the world in terms of campus pollution, operations, etc., shows how the people within the HEIs community have been changing the natural systems of the world. If the HEIs communities across the world fail to address how they have been alternating the natural system, nature will not be considered as being natural in the shortest period.

On the other hand, Vitousek et al. (1997) claimed that humans' ecological footprint is responsible for various environmental degradation and land transformation via land clearing for various developmental projects and constructions. Such construction or development establishes HEIs campuses that mostly occupy a massive expanse of greenbelts and land designated for conversation. As a result, the Anthropocene advocates posited that human beings had turned themselves into monsters with excellent capability to reshape the planet earth (Lövbrand et al., 2015). This monstrous reshaping of the world has got to a situation where “natural forces and human forces are so intertwined that the fate of one determines the fate of the other” (Zalasiewicz et al., 2010 p. 2231).

The Anthropocene philosophical approach could contribute a lot in resolving most of the challenges this study aims at resolving. When the concept of Anthropocene is applied to CSA, the generalization of the impacts of human activities within the HEIs campus might be limited to the people's local environment and cultural value system within the study area. One central research question mostly asked when conducting Anthropocene studies is: *How can and should different human and non-humans' actors and actions be understood in their totality?* This research question is applicable in this research project and provides room for the Anthropocene researcher to research this topic in the approach that will be briefly explained below.

A comprehensive review of the literature reveals that the Anthropocene researcher's first action conducting a topic related to this research is to reframe the research question to address their study topic. The topic could be reframed to, for instance, *how can people's environmental sustainability actions within the HEIs campus community be understood in their totality?* Providing answers to this question could require the researchers to identify several humans' sustainability attributes peculiar to the local environment and society that the research is being conducted and, after that, assess the people based on these attributes. The researcher will also have to identify how the people within the HEIs communities harm the campuses and the whole world (i.e., greenhouse emissions) and develop ways to resolve this challenge. The researcher will also have to develop ways in which people within the HEIs campuses will work together toward ensuring that they make the HEIs a better place for all stakeholders and all humans.

Several pros of the Anthropocene apply to this research. The Anthropocene concept mostly seeks an understanding of the consequences of human actions that include energy consumption and changes in various land uses (Lövbrand et al., 2015). If this theoretical basis is adopted, this understanding of human action consequences is advantageous and a form of overlap between Anthropocene and this research. When doing Anthropocene-related research, the researchers are expected to identify how humans have contributed negatively to Earth. Humans' negative contribution is another merit of this leading social theory. Identifying students, staff (both teaching and non-teaching), and all relevant stakeholders within the HEIs campuses in the study area is essential for this research. The sustainability assessment framework that would be proposed during this research project could be an excellent and welcome development in this research field and might also help understand how to eliminate humans' adverse effects on the whole world.

Another approach to researching Anthropocene-related studies is the development of several ways human beings could work jointly to improve the world. This collaboration also serves as another edge. The sustainability assessment framework that this research aims to establish seeks to formulate a set of policies that would serve as strategies to ensure that the people within the HEIs community develop cooperation in improving the sustainability level and performance of their institutions and, in the long run, improve the planet earth. The framework could also help curb campuses' challenges, such as pollution, environmental degradation, poor and inadequate housing, mobility, security, and lack of adequate social amenities.

The idea that the world is now in a situation whereby human activities have dominated the world has led to the establishment of various research funding, scholarships, collaboration, and even an international peer-reviewed journal (Lorimer, 2017; Lövbrand et al., 2015). Conducting a research project using Anthropocene's philosophical approach or concept is likely to raise research funds for campus-based sustainability appraisal research in the nearest future. According to Brito et al. (2012), "that challenges facing a planet under pressure demand a new approach to research that is more integrative, international and solution-oriented." Anthropocene-related research, such as impacts of the HEIs on the environment, could also lead to several research collaborations since it is difficult for just one academic discipline to comprehensively and effectively address all the complex environmental challenges that are currently being experienced by the planet earth.

Despite some of the advantages of applying the concept of Anthropocene in sustainable campus research, there are also other challenges of using Anthropocene's philosophical thinking in this research. Studies conducted by researchers such as Eyles & Elliott (2001); Liverman (2009) observed that the consequences of human activities and social drivers are sometimes overgeneralized, leading to complications and challenges at the local level. The Anthropocene philosophical approach could make some of this research's findings overgeneralize the challenges identified within the HEIs campuses in the research case study. This overgeneralization is one of the significant disadvantages of this theory to this research. Another disadvantage of the Anthropocene in this research is an observation made by Lövbrand et al. (2015) that the concept has not been presented in a positive and optimistic narration of human development. The concept narratives always focus on the crisis, deadlines, and urgency in resolving the challenges. This narrative will not give room for research, such as one currently pursued to formulate long-term policies and strategic solutions. Anthropocene research is also mainly concentrated on in-depth and global knowledge. On the contrary, this research concentrates on understanding the profound impacts of HEIs within Nigeria and links them to the world. This concentration on global knowledge could limit the findings of the research and provide an avenue for criticism.

4.4.1.2 Theory of Functionalism

One of the earliest theories of social sciences is the theory known as Functionalism. Its strands are an objective description of societies, the definition of human societies, identification of problems in societies, and the proposal of solutions for societies' development (progress). Some of its methodologies are (i) observation (actions, statements, contexts), (ii) analytical evaluation of evidence, and (iii) logical conclusions about society. It has several advantages: system-oriented (evaluation, improvement), repeatable research (observations, analysis, theorizing), and its applicability by any discipline. One of its disadvantages is placing less importance on societal individuals. With this theory, if individuals do not ‘fit in,’ they need to be educated better or slip into anomie. It also claims that everything that exists or happens is a social fact and that society is never ‘wrong.’ At worst, parts of its AGIL (Adaptation, Goal Attainment, Integration, and Latency) system are out of balance.

The major proponents of this theory are Auguste Comte (1798-1857), Emile Durkheim (1858-1917), and Talcott Parsons (1902-1979), while others are Robert Merton (1910-2003) and Claude Levi-Strauss (1908-2009). Emile Durkheim (1858-1917) Functionalism approach to societies is based on (i) the premise that human behavior can be predicted from a study of a person's past, (ii) societal laws can be predicted from a study of society's past and (iii) finally that causes and effects can be turned into predictive rules of potential actions or social facts. Auguste Comte (1798-1857) positivism approach is based on (i) external phenomena, (ii) no knowledge of 'hidden things,' and (iii) that knowledge is relative to (a) the 'collective human observer' and (b) truth criteria of a specific age. Talcott Parsons (1902-1979) created a more flexible system for studying and describing societies. He developed the AGIL system, as depicted in **Figure 4.2** below.

	INSTRUMENTAL	CONSUMMATORY
EXTERNAL	• **Adaptation** - The ability of a society to interact with its environment ✓ Natural environment ✓ Neighbors ✓ Systems of collecting and distributing resources	• **Goal Attainment** - Being able to set goals and to make decisions to achieve them ✓ Political systems ✓ Societal organizations
INTERNAL	• **Integration** - Including everybody in society - Balancing different groups - 'Fairness' ✓ Common language ✓ Common access to resources ✓ Common goals	• **Latency (=Pattern maintenance)** - Institutions that reproduce society ✓ Family ✓ School - Institutions that maintain stability ✓ Legal system ✓ Belief system

Figure 4. 2: Parsons's AGIL system

He posited that all societies can be plotted using the abstract AGIL system and that it can be applied to societ(ies) or parts of societ(ies). The overall aim of using this system is to improve society. Using this philosophical approach, researchers analyze societies and their constituent parts, thereafter identifying and suggesting solutions to AGIL deficiencies or tensions.

The theory of Functionalism is also closely associated with the proposition of *progress of* Emile Durkheim (Weber, 1917) and *the positivism of* Auguste Comte (Mill, 1865), and its application is still relevant in many fields such as engineering and physical sciences. Its applicability is very pertinent and appropriate in the discipline of campus planning and green campus. The theory perceives socialization from the concept of institutionalization where different specialized organs (i.e., media houses, religious institutions, family, and school system) of the society handle socialization (Musgrave, 1971). In this research, the part of the society being focused on is the school system (i.e., HEIs). Despite its less importance on individuals, Functionalists still believe that every member of society is essential to its successful organization and civilization. This importance of societal members is directly related to this research because every HEIs stakeholder is paramount in ensuring a better sustainability performance of HEIs campuses, eventually leading to a sustainable and livable world. If adopted, the functionalist theory could shape this research into studying global society via assessing the impacts of HEIs in Nigeria on the universe. In other words, it could guide this study to formulate policies and guidelines that will seek to improve human society by first ensuring that various HEIs across its case study eliminate their negative impacts on society.

In **Chapter 1**, a discussion on how campuses of HEIs could be likened to that of the cities because of their expanse land area, and several land uses and complex operations, activities, and transportation (Alshuwaikhat & Abubakar, 2008) were presented. In other words, they can be referred to as small-scale societies. While Functionalism proponents seek to objectively define and describe the human societies (Musgrave, 1971), this research also seeks to report the campus-wide sustainability performance in HEIs campuses via objective assessment like Talcott Parsons' AGIL (Fararo, 1993). Besides, functionalism theory aims to discover, recognize, and confront human society's challenges (Musgrave, 1971). In line with this theoretical approach, its adoption would seek to identify various sustainability challenges within Nigeria HEIs and thereafter formulate policies that will ensure that these drawbacks are adequately addressed and prevented from creating a socio-economic and environmental impact on the global cities.

Functionalists adopt some of the methodologies in conducting their research: observation and evaluation before arriving at logical conclusions about the society under investigation. In the same vein, if incorporated, there might be the need for a study trip that would involve campus observations, interviews, and collection of university sustainability reports, surveys, and workshops, as well as social media data extraction of information on the sustainability of campuses in the case study campuses. Analytical evaluation of the data could be conducted before arriving at a logical conclusion about HEIs' sustainability performance in the case study with continuous monitoring and review.

The theory has many advantages regarding CSA. Since CSA concentrates on small-scale societies, there is a perceived correlation between the theory and this CSA study. They both focus on human societies. Concerning the ideas of progress and positivism (Mill, 1865; Weber, 1917) that is rooted in evaluation and improvement under the broad heading of system-oriented, this is perceived as an advantage to the development of an appraisal framework that will eventually be utilized to evaluate the sustainability performance of HEIs campuses. The appraisal outcomes could lead to the formulation of measures that could ensure the amelioration of the practical sustainability challenges (if any) and the eventual enhancement of the situations. The application of functionalism eliminates the non-repeatability or non-reproducibility challenges of CSA research as it ensures several observations and analyses (i.e., monitoring and review).

Despite the identified merits of this approach to this study, other identified cons include but are not limited to the following. (1) The proposed framework's flexibility might not be guaranteed as the AGIL system could only cover part of the significant campus sustainability attributes that the proposed framework seeks to utilize in assessing the level of HEIs sustainability performance (**see Chapter 2**). (2) Unlike the Interactionism theory that places high importance on the individual within the society, functionalism does not place immense importance on the individual within the society. This lack of attention to societal individuals is another limit to this research. This research seeks to pay attention to individual stakeholders' roles within the HEIs campuses regarding their perception, awareness, level of importance, sustainability practices, etc.

4.4.1.3 Theory of Symbolic Interactionism

Social scientists during the early 1990s posited that the theoretical perspective of symbolic interaction is well-grounded in social science research. In contrast, earlier scholars during the mid-1970s had already verified its compatibility with quantitative methodology research (Benzies & Allen, 2001). The theory of symbolic interactionism started during the 20th century as a way of describing the urbanization and the industrialization challenges of that period. It is based on the assumption that human beings' perception of their environment is subject to their construction of that environment. This approach was utilized by John Dewey (1859-1952) to resolve the societal challenges of his era. The perspective of symbolic interaction used in language differentiates humans and their community from other living creatures.

The foundation of its perspective can be linked to sociology. Some of its premises could be found in the ideas of Charles Horton Cooley (1884-1929), George Herbert Mead (1863-1931), and Erving Goffman (1922-1982) during the 18th and 19th centuries. These sociologists work on concepts that were later expanded upon, such as looking glass self, the "I" and the "me" and everyday drama. The theory could also be related to the concept of environmental determinism and Darwin's theory of evolution. Both concepts are based on the environment as the determinant factor of human behavior, and these behaviors are constantly changing as a result of human interpretation. Some of the ideals of symbolic interactionism, such as the recognition of overt and covert human behavior, are also derived from Behaviorism (Charon, 1995). Sociologists such as Mead, Dewey, and Cooley during the 20th century are of the perspective that the meaning of an object is not within the object but rather in the mindset humans have toward the object. A couple of scholars are in agreement that these sociologists' views have the highest substantial basis for the symbolic interaction theory (Charon, 1995).

Herbert Blumer (1900-1986), who is a student of George Herbert Mead (1863-1931), coined the term symbolic interaction. While Mead's work is centered on the "I" and the "me" that was modified from the concept of the "mind" and the "self," Blumer's work of symbolic interaction serves as a replacement for Functionalism and Behaviorism theories during his lifetime. However, its expansion and adoption after Blumer's demise led to the theory's splitting into the Iowa and Chicago school of thought. The Chicago school of thought concentrates on the understanding of individual's perception of its environment with a focus on the individual's observation, focus group, past events and experiences, autobiographies, record and notebooks, interviews, dossiers, and case studies to generate theories and outcomes that are based empirical information (Blumer, 1969). This school of thought is grounded on repeated evidence. The reliance on evidence and the approach of conducting studies based on the Chicago school of thought is related to the CSA study being pursued in this study. If this theory is adopted, it will assist in the extraction of HEI stakeholders' information on attributes of sustainable campus on a case study basis.

The Iowa school of thought was credited to Manford Kuhn (1911-1963) and later expanded by Couch and other sociologists at the University of Iowa (Benzies & Allen, 2001). Unlike the Chicago school that assesses human societies based on the detailed inquiry of histories, events of the past, etc., the Iowa school concentrates on developing a verifiable and anticipative social behavior analysis. Empirical methods are the basis for testing studies of social behaviors. Methods of information gathering used in this school include but are not limited to the questionnaire survey, extraction of analyzed survey data, statistical analysis, ethnomethodological, lab tests, and experimental procedures (Benzies & Allen, 2001). This method can be referred to as a structured approach. After the demise of Manford Kuhn, the Iowa school broadened the understanding of human social behavior to an external observer in the process of data collection. As such, the Iowa school methodology also overlaps perfectly with the CSA model development process of data collection that requires survey data and distribution of questionnaire surveys to experts within this field.

The theory of symbolic interactionism is based on three underlying assumptions (Benzies & Allen, 2001). These are (i) people, individually and collectively, act based on the meanings that things have for them (ii) meaning arises in the process of interaction among individuals (iii) meanings are assigned and modified through an interpretive process that is ever-changing, subject to redefinition, relocation, and realignments (Shalin, 1984 p.544). These assumptions bind together the stages/process of developing a flexible model that matches a specific society's nature and cultural norms, such as the study's case study. This model's flexibility will be based on the individual and collective choice that could be modified via an interpretive procedure that continuously changes subject to necessary realignment.

Applying this theory's tenets to social media techniques could reveal the understanding of the campus sustainability situation in the study's case study based on individuals' perspectives on social media platforms. This theory has a great capacity in advancing the comprehension of human sustainability behaviors within HEI campuses. This potential will be justified after studying the theoretical approaches that have been utilized in existing CSA tools. If adopted, validation via empirical methodology and statistical analysis will justify its pragmatic application and, most importantly, its contribution to urban and campus planning advancement.

4.4.1.4 Interactionism

Interactionism aims to interpret society's interpretive understanding, the historical development of societies, societal rationalization processes, and the individual problems with rationalization. The theory focuses on individuals who are perceived as limited and oppressed by increasing rationalization and normalizing societies. It states that individual actions have the power to change societies. When using this approach to conduct research, methods such as observation (involving direct and or analysis of thought processes), the abstraction of salient actions as ideals, and extrapolation of causes and effects are utilized. One of the approach's advantages is that it looks at people 'behind' institutions (such as universities) and their interactions. It also focuses on people's motivations. On the other hand, some of its disadvantages are being too rationalistic and theoretically jumping between individual observations and global conclusions.

This theory could be linked to Max Weber (1864-1920), who lived through the end of the 19th century and World War I. He came up with an explanation of society through the interpretation of social actions in rational societies. He believes that everything that happens in society results from individuals' social actions. A social action considers other (re-)actions, influences other actions, and individual 'agents' acts in society (see **Figure 4.3**). Successful social actions become patterns for later social actions. He also opined that it is possible to trace chains of social actions through their causes and effects. To Weber, successful social actions become part of rational structures (i.e., bureaucracies and economic rationalities). These patterns allow society to run more efficiently (i.e., more rationally).

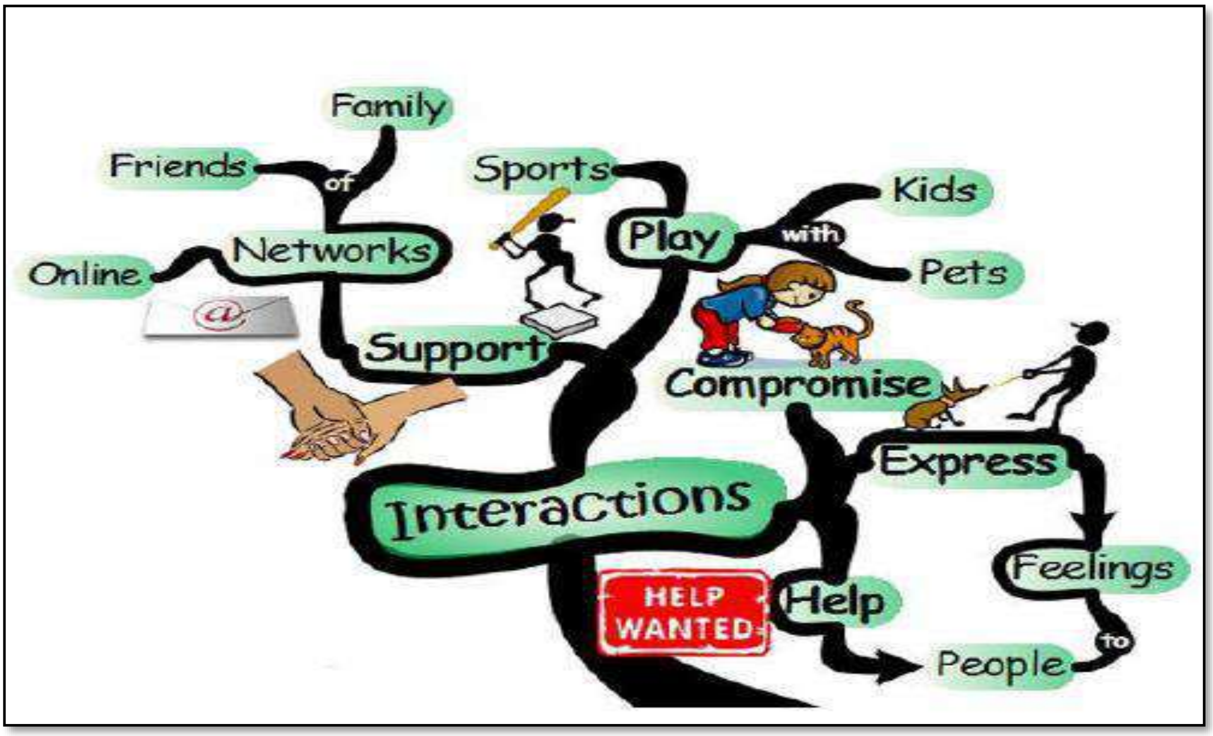

Figure 4. 3: Never-Ending Nature of Interactionism

The theory of interactionism is concerned chiefly with rationalizing human activities and processes within the society to bring about orderliness and the avoidance of chaos (Shalin, 1986). The application of this theory is very relevant in Urban Planning, City Design, and Architecture. This application is evident in the life of Interactionists, such as Georg Simmel. Interactionists view socialization as the continuous interaction between every member of the society that mostly ends with some consequences due to behavioral imitation. The interactionism theory can be adopted to guide research in assessing individuals' sustainability practices (students, staff, and all stakeholders) in every HEIs campus within Nigeria to understand how their behaviors affect these campuses' sustainability pillars. This understanding could be followed by assessing the individual HEIs campuses' sustainability practices within the country to observe their impact and the eventual consequences on the global village. It should also be noted that Interactionism aims to create ideal types (patterns) of behavior, definitions of social actions, and historical explanations of society (i.e., causal chains of social actions), which directly overlap with some of the objectives of this research.

There are a few merits of utilizing this philosophical approach to this research. The theory is advantageous to this research because it focuses on individuals' social actions within a community. This focus is in tandem with this research that seeks to develop a model that will assess and identify the individual sustainability actions within a HEIs campus. If adopted, the theory of interactionism can provide this research with the justification of tracing the causes and effects of the absence or non-implementation of sustainability practices (if any) based on the individuals (such as students and staff) within the Nigerian HEIs campuses. The historical development of HEIs campuses as a mini-society with a particular focus on their sustainability practices over time could also be effectively discovered using this theory. In line with the achievement of economic sustainability performance via the adoption of Marxism, it could also be achieved with interactionism's adoption because of its efficient economic rationalization.

On the other hand, some of the demerits of adopting this theory into this research are due process and bureaucracies that will be involved in implementing the proposed model. This process is similar and related to those identified by scholars in extant literature (Alghamdi et al., 2017; Shriberg, 2004; Sonetti et al., 2016). Without adopting other quantitative methods such as decision analysis, it will be erroneous to generalize the impacts of individuals' social actions on the global cities. For example, this theory could be used to conclude the study of individual sustainability actions to justify climate change challenges and other environmental issues. However, verifying such conclusions using empirical findings could be difficult to achieve without other quantitative research methods.

4.4.1.5 Marxism

The last leading social theory with a philosophical approach that aims to solve human society's challenges considered for review in this chapter is Marxism. It focuses on the critique of modern society, emphasizing people's relationships, the role of the economy in society, and modernity improvement. It also concentrates on social development analysis, such as definitions of society, possibilities for development, and directing change. Its central point is the identification and overcoming of the various shades of societal imbalance. The major proponents of this approach are Karl Marx (1818-1883), Vladimir Lenin, Joseph Stalin, Mao Zedong,

Besides, it is also directed at analyzing the development within the society by defining its ideal society with the feasibility of achieving improvements and piloting the people's affairs toward a radical change. It views socialization as the economic integration of humans (i.e., workers and capitalists). Its paramount aim is the identification and the eventual defeat of the injustice (alienation or imbalance) that exists in virtually all modern society. This theory's aim is in tandem with research that seeks to assess the economic sustainability imbalance of HEIs campuses. Utilizing Marxism's theory to study the economic sustainability of HEIs campuses within Nigeria to dissect their economic situations can help resolve a more significant percentage of these challenges. The oppression and the injustice between the HEIs staff (workers) and the HEIs investors or financiers (capitalists) can also be examined using the Marxism theory to determine the economic sustainability performance of HEIs in Nigeria and, by extension, to the global cities.

One of the advantages of Marxism to campus sustainability research is its focus on human societies. It also seeks to identify the problems within a society, while this study seeks to address the sustainability challenges in HEIs campuses. However, this theory is based on revolution principles, which are contrary to this research. Overall, the study aims to formulate planning strategies and policies to ensure that the identified challenges were adequately resolved after implementing appraisal on campus-wide sustainability attributes of HEIs in the study area based on the proposed model.

After a comprehensive review and comparison of the main social theories (see **Table 4.2**), the findings reveal the perspectives of the selected five social theories. These perspectives show the validity and reliance on their outcomes when adopted in CSA research. However, the adopted theory as a theoretical basis for CSA research is based on the study's aim, which is subjected to the participants of sustainable campus appraisal, which are mainly social media users.

Table 4. 2: Comparison of the selected main social theories

	Functionalism	**Marxism**	**Interactionist Theories**	**Symbolic Interactionism**	**Anthropocene**
Emergence	Early 19th century	Late 19th century	Late 19th century	Early 20th century	Early 21st century
Target	Society	Society	Individuals	Individuals	Society
Perspective	Positive	Negative	Positive	Positive/ Negative	Negative
Research object	Social facts	Dialectic	Social actions	Individual actions	Human actions
Research methods	Extrapolation, Extinction, Deduction	Relations of Production, Classes, Class Struggle	Direct Observation, Explanatory, Understanding, Casual Understanding	Focus Group Observation, Interview, Questionnaire Survey	Collaborative, International solution-oriented

Output/Outcome	Scientific descriptions	Revolution	Historical explanation	Behavioral descriptions	Deconstruction
Major Proponents	Talcott Parsons, Auguste Comte, Emile Durkheim, Claude Levi-Strauss	Karl Marx, Vladimir Lenin, Antonio Gramsci	Max weber, Erving Goffman, Mikhail Bakhtin	Charles Horton Cooley, George Herbert Mead, Williams James, Everett Hughes	Eduard Seuss, Vladimir Vernadsky, Gorge Perkins Marsh
Applicable to	Physical sciences, Psychology, Engineering	Social and Political Activists	Psychology and Social Scientists	Numerous Disciplines	Numerous Disciplines
Sustainability Pillar	Social	Economic	Economic, Social	Social	Environment

4.4.2 Adoption of Symbolic Interactionism

After the five main social theories' critical appraisals, the theory of symbolic interactionism was adopted for the interpretation and context for CSA, model development, and campus design for sustainability, QOL, and livability. Different methodological approaches within the perspective of symbolic interactionism provide room for conducting CSA and determining the level of awareness, priorities, and localization of campus sustainability attributes based on the UGC of HEIs stakeholders on various social media platforms. Understanding the importance of preferences that humans attach to things within their external environment is paramount within the tenets of symbolic interactionism. This perspective is relevant and needed in the appraisal and management of sustainability achievement in HEIs. Obtaining information and a vast volume of data from different contexts about the concept of sustainability within HEIs from social media platforms and opinion surveys from experts in the field will provide a better understanding of indicators or topics that stakeholders attached importance to.

The theory of symbolic interactionism has strong epistemological assumptions that ensure smooth incorporation with other philosophical and theoretical bases (Benzies & Allen, 2001). For scholars that utilize more than one methodology to validate their hypotheses or arrive at their research conclusion, a theoretical perspective for logical and comprehensible results is provided by symbolic interactionism. Suppose the concept of sustainability is integrated with the theory of symbolic interactionism. In that case, it tends to ensure sustainable assessment in developing countries at an early stage of sustainability implementation.

Individual perceptions and interpretations of the physical environment are one of the bases of symbolic interactionism. New meanings and approaches to responses within human societies are regularly achieved via stimuli interpretation leading to a sustainable society resulting from the procedure of meaning interpretation. Another assumption of symbolic interactionism is the fact that communication and interaction are possible between humans based on the agreed meaning associated with the objects in their culture and external world. Another premise of symbolic interactionism is that the meaning attached to things changes over time based on individual context. This tenet of symbolic interaction supports the need for the Spatio-temporal dimension of sustainability within HEIs campuses to allow for continuous monitoring and review of human perception and importance to the level of sustainability within these campuses. This is because the current state of things and situations can be fully understood via human interpretation of actuality within societies. It is imperative for scholars studying the Spatio-temporal dimensions of sustainability of the HEIs campus to study the history and past experiences of the groups and or individuals within the study's scope. Identifying individuals and their perceptions based on time and past views necessitate the Spatio-temporal dimension, which continuously monitors events over time.

With the incorporation of this theory into the existing CSA framework, the meaning that the participants of the study attached to sustainable campus could be revealed based on the socio-economic, environmental, and cultural values key stakeholders of HEIs attached to campus sustainability and sustainability attributes within specific geographical regions or higher education. With higher awareness, comments, likes, etc., the campus sustainability attributes could be given more priorities and preferences. **Figure 4.4** below depicts symbolic interactionism's integration into identifying and selecting HEIs sustainability indicators using social media UGC.

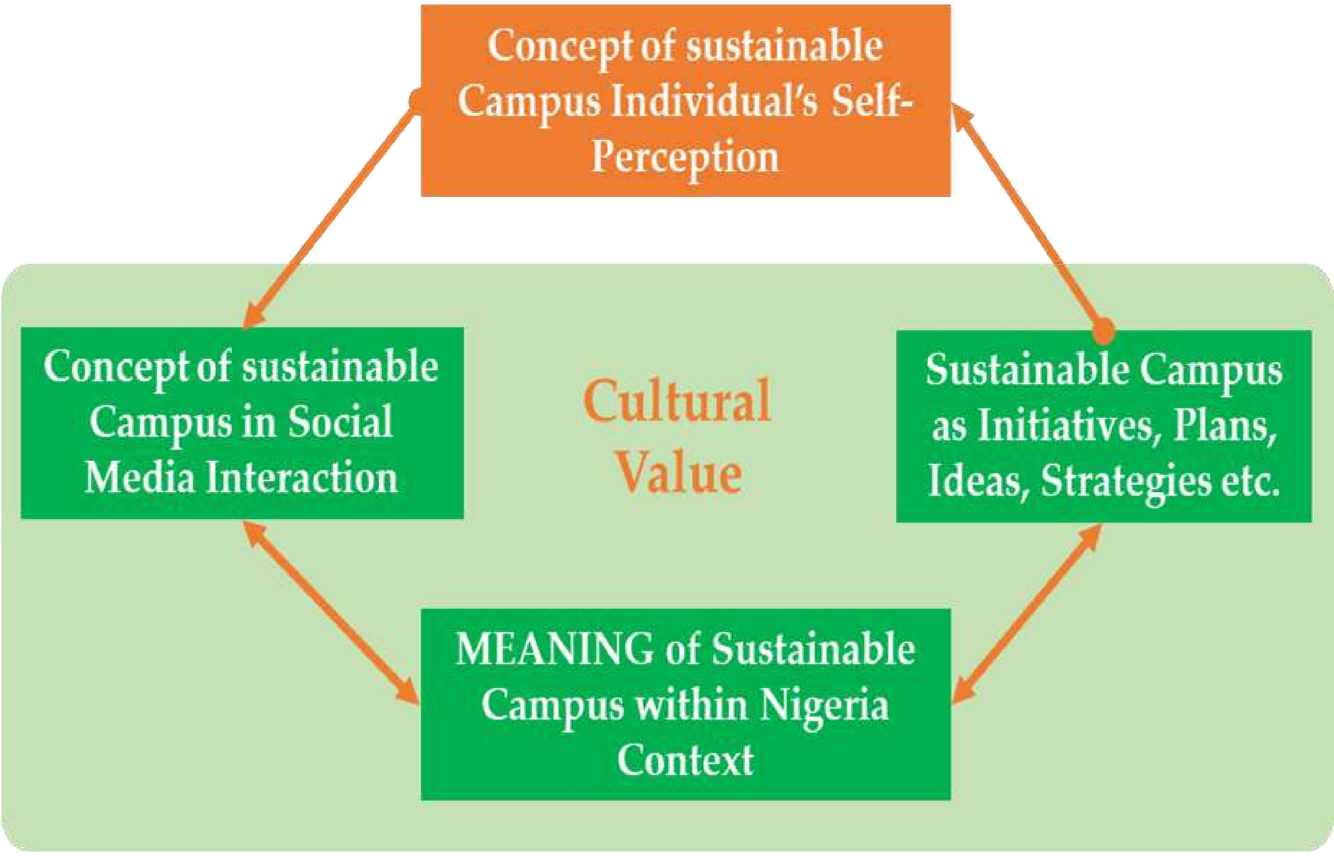

Figure 4. 4: Campus Sustainability appraisal and Symbolic Interactionism

4.4.2.1 Operational Synthesis of the Symbolic Interactionism Theoretical Framework

The operational synthesis of this study's theoretical framework showing the linkages between individual social media action and joint social media actions based on similar cultural values, social norms, public awareness, etc., is illustrated in **Figure 4.5**. Discussion on the various framings and the linkages to establishing campus sustainability indicators via social media symbols and conversation is also depicted. The theoretical model of symbolic interactionism was adapted from extant studies (Kwon, 2017).

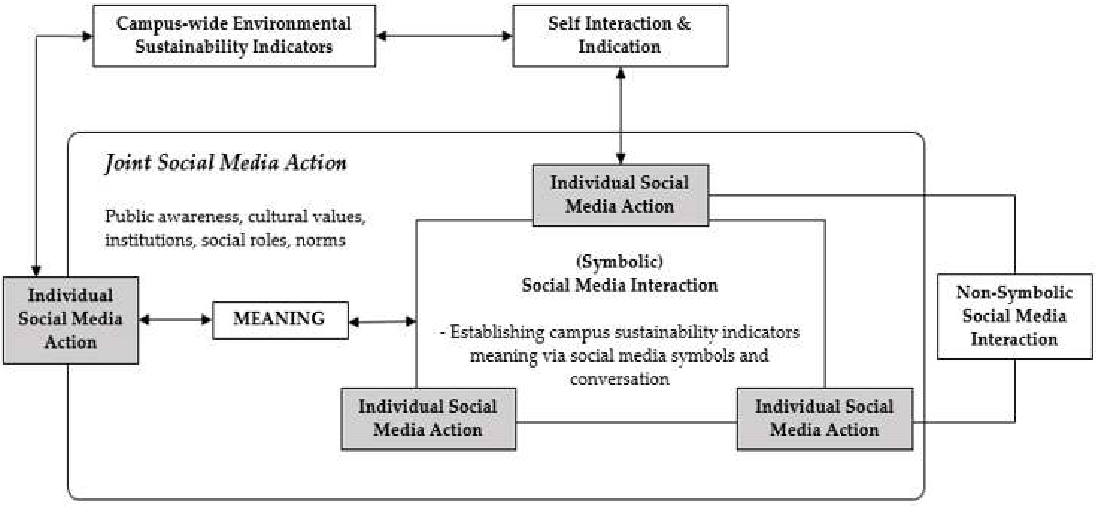

Figure 4. 5: Operational Synthesis of the Theoretical Framework

The following section presents the applicability of the adopted theoretical basis based on a pilot study conducted in a West African nation (Nigeria) where the status of the sustainability performance of HEIs is presently unknown.

4.4.3 Pilot Study: Identifying Spatial-based Attributes Preferences for Campus Sustainability in Lagos Mega City

Currently, a high percentage of studies relating to higher education and sustainability give more preference to hypothesis testing, utilization of mathematical equations and software, etc., rather than the adoption, creation, expansion, incorporation, validation, and verification of theoretical approaches/frameworks. If this trend is not corrected, campus planning, appraisal, and design for sustainability studies will lack knowledge contributions and a theoretical basis for guiding these endeavors. In campus planning for sustainability and QOL, the planning theory aspect relating to behavioral relationships and public welfare could be linked with symbolic interactionism's theoretical perspective. The more a discipline becomes complex in social sciences, the more it needs for theory creation, incorporation, and adoption. Theoretical perspectives assist in the process of decision making, policy issues deliberations, and evaluation of policy effectiveness. The identification of the preferences of campus sustainability attributes using social media UGC provides a real-life scenario to test the applicability of the tenets of symbolic interactionism in a university in Lagos megacity, Nigeria.

4.4.3.1 Brief Description of Universities and Selection of a Study Area in Lagos Mega City

Currently, Lagos's estimated population is 13.7 million and occupies the 17th position among the largest megacity of the world (United Nations, 2016). Lagos' status as a megacity is one of the reasons for selecting a university for this study because only Cairo in Egypt and Kinshasa in DR Congo have the status of megacities in Africa. Also, unlike the two cities of Tokyo and Osaka in Japan that have been projected to experience a decline in growth rate; the city of Lagos has been continuously experiencing an annual growth rate of 2.5% and a 5% population increase from 1970 to 1990. The astonishing projection states that the city will become the largest city in the world by the year 2100 (Desjardins, 2017).

Figure 4. 6: World map showing the location of Lagos megacity

Investigation and comprehensive review of the literature reveal that the annual increase in the number of people residing in Lagos is due to the movement of people from nearby countries and other parts of the country for studies in several HEIs.

There are currently eight universities in Lagos megacity: two federal government-owned, one state-owned, and five that private establishments own. The two federal government universities are the University of Lagos and the National Open University. While the University of Lagos is located on three campuses across the city with the main campus at Akoka, the National Open University is an open and distance learning higher institution with various campuses located across the country, including the city of Lagos. With the main campus located at Ojo, the Lagos state university is the only state-owned institution in Lagos city. The remaining are privately owned universities located across the city on a small land area. The privately established universities are Anchor University, Augustine University, Caleb University, Eko University of Medical and Health Sciences, James Hope University, and Pan-Atlantic University.

From amongst the HEIs, the University of Lagos main campus, a top-ranked university in Nigeria that was established in 1962 in the coastal city of Lagos, was selected for the application of the theoretical basis. The University was selected for the application of the proposed approach because it possesses some principles of a sustainable campus, which include but are not limited to the (i) allocation of a large area of land for the establishment of a botanical garden, (ii) presence of sustainable infrastructure, (iii) preservation of its vast green area, and historic buildings, and (iv) presence of natural Lagoon waterfront.

4.5 Research Findings

4.5.1 Environmental-dimension Attributes with Spatial-based Campus Sustainability Indicators

In ensuring the identification of campus-wide sustainability attributes preferences based on the basis of symbolic interaction, 220 indicators with 266 sub-indicators across 55 categories from the 13 extracted

CSA tools in **Table 4.1** were extracted. Detailed discussion and explanation of the environmental-dimension attributes have been presented in **Chapter 2**. However, a brief recap is discussed in line with the adopted theoretical basis in this sub-section.

After the above extraction, they were filtered to ensure the selection of environmental-dimension attributes with campus-wide indicators. A large number of spatial data within HEIs campuses' framework could be obtained without any dependence on official data that are either restricted or unavailable. Spatial decision support systems ensure that indicators with spatial dimensions provide smart referenced-based campus planning and decision making that could be monitored and reviewed based on one of the tenets of symbolic interactionism. This filtering limited the categories, indicators, and sub-indicators to 13, 50, and 65, respectively.

Afterward, repeated campus sustainability attributes or with similar technical meanings were merged and subjected to SMART Approach. This merging ensures that the attributes are: (1) Specific: A reliable attribute must be specific (i.e., discrete to avoid confusion during a CSA application). A specific attribute is clear to the HEIs stakeholders and defines the domain in which the whole campus-wide assessment will be carried out. It is also founded on available, accessible, and accurate information. (2) Measurable: A sound attribute must be measurable. A measurable attribute is bound to possess a certain discrete numerical value as well as a standardized unit of measurement that is acceptable all over the world. The measurable property of the attribute also assists in the statistical analysis of the framework. (3) Achievable: One of the prime properties of good attributes is that they are achievable. If an attribute cannot be achieved, it is impossible to utilize the symbolic interactionism approach and come up with conclusions and results. The attribute will then be merely a hypothetical one. Attributes should also reflect the HEIs' capability to effect change, linked to the precise and complete goals of the HEIs and based on the democratic inclusion of stakeholders in their selection process. (4) Relevant: Another quality of a good attribute is an ability to be robust and relevant to overall assessment objectives as well as local and global sustainability challenges. They should also be comparable to the local and contemporary context and meet campus stakeholders' key needs. Also, in selecting attributes, consideration is given to their data collection, documentation, and maintenance ability. Irrelevant attributes complicate the indicator framework and the whole assessment process. (5) Time-specific: Lastly, as attributes are measurable entities, notable change over a specific time is an important feature of indicators for CSA. Sound attributes have longevity, which means attributes should allow for repeated measurement and be adaptive to change based on one of the tenets of symbolic interactionism. The outcome of the SMART Approach is already presented in Chapter 2.

4.5.2 Twitter Social Media UGC Mining Based on Symbolic Interactionism Premise

To demonstrate symbolic interactionism in campus appraisal for sustainability, a pilot study was conducted via the use of (i) Elastic stack (i.e., data mining open-source product) and (ii) Python 3 Library: GetOldTweets3 to mine Twitter social media UGC from an account of a university in Nigeria (West Africa) to establish the preferences of the selected campus sustainability attributes. For convenient data analysis, Python programming language was utilized in transforming the UGC in comma-separated value (CSV) to JavaScript Object Notation (JSON). A detailed description of the methodology is presented in Chapter 3.

The official Twitter handle of the university (@UnilagNigeria) has had more than 10,000 followers since its creation in 2017. Unlike other HEIs' Twitter account, the Twitter account of the University of Lagos has UGC involving green campus and sustainable development that are frequently updated. In this pilot study, 1,989 UGC generated by the social media users between May to July 2017 was extracted based on the first tenet of symbolic interactionism, although the university Twitter account has UGC in thousands.

The second tenet of symbolic interactionism states that "meaning arises in the process of interaction among individuals" (Shalin, 1984 p.544). The meaning individuals attached to the concept of campus sustainability will become evident on social media due to continuous interactions amongst social media users. This meaning will become evident in the comments, likes, and retweets. This pilot study reveals the meaning behind every post on Twitter by also mining the comments underneath them. A questionnaire survey was later distributed to experts within the university to validate the applicability of Twitter likes, comments, and retweets. This survey was done to determine their weight and the formulation of the equation for defining preferences given to the campus sustainability attributes discussed during social media interactions. Twenty experts in four different academic departments of the university were visited. Five experts each from the Department of Computer Sciences; Urban and Regional Planning; Sociology; and Systems Engineering. The weights of replies, retweets, and favorites are 3, 2.85, and 3.1, respectively. The campus sustainability attributes preference equation is defined as follows:

$$S_p = \frac{R_p(3.0) + R_t(2.85) + F_t(3.1)}{S_{p_{max}}} \tag{1}$$

Where S_p represents campus sustainability attributes preference, R_p, R_t, F_t representing replies, retweets, and favorites; and $S_{p_{max}}$ represents the maximal campus sustainability attributes preference.

Still, with the use of social media tags, other users can react by making comments, likes, or retweeting because they agree on the meaning attached to the topic. It was agreed that tweets with fewer likes, retweets, and comments have fewer individuals who agree with meanings attached to them. Better still, they are of less awareness or did not match the nature and the present challenges/needs of HEIs. They are therefore given less level of preference for sustainability appraisal. At the end of the data analysis stage, the energy and climate change category had the highest preference level. This is followed by waste, water; setting and infrastructure; environment, and lastly, transportation. Unlike **Figure 4.4**, which depicts the general incorporation of a symbolic interactionism basis in CSA, the framework for determining the campus sustainability attributes preference for the selected university is depicted in **Figure 4.7**.

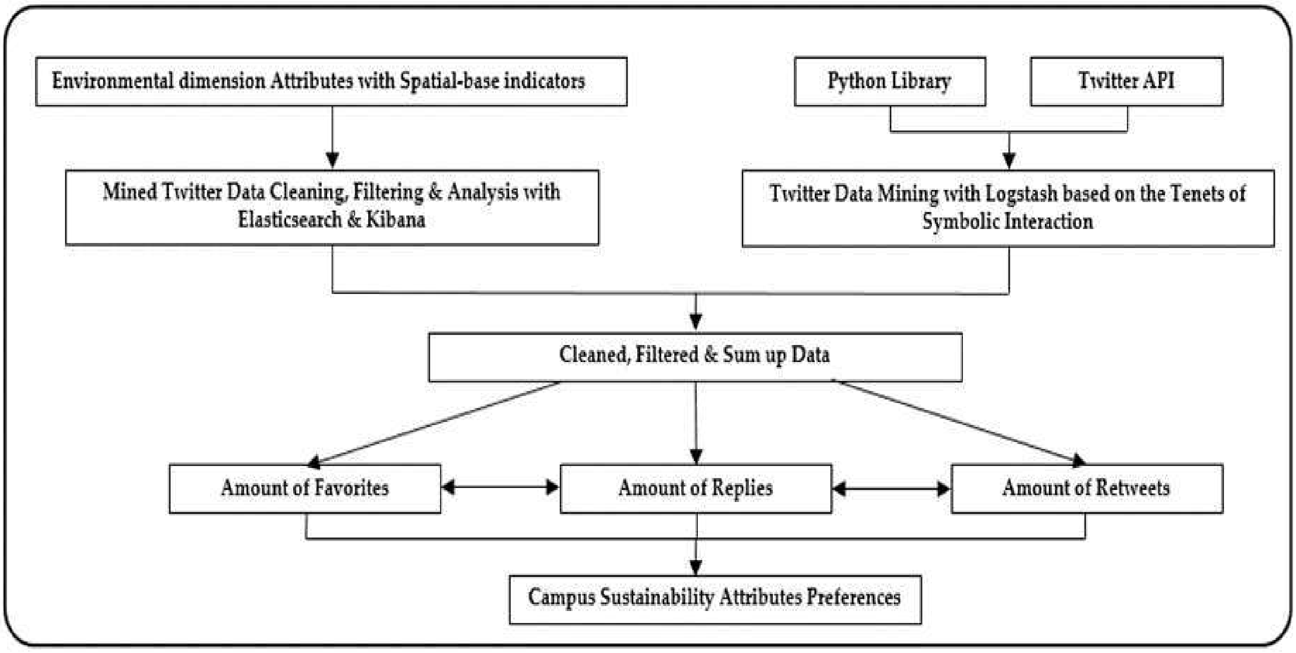

Figure 4. 7: A framework for identifying HEIs attributes preferences

4.6 Discussion and Implication for Sustainability in HEIs

The first tenet underpinning symbolic interactionism is that humans interpret the world via the utilization of symbols when they are communicating with themselves. Also, Charles Cooley was reported to have mentioned that the human mind is the action that channels the utilization of symbols toward self (Charon, 1995), based on the concept of "social self" by Williams James. Therefore, when conducting a symbolic interactionism study of understanding others, the researcher is a role projected by an individual to identify language symbols being used. The UGC with Twitter tag symbols were identified and thereafter filtered and analyzed to obtain sustainability attributes contained in the UGC with the highest likes, replies, and retweets. The results were analyzed using the campus sustainability attributes preference equation adopted and modified from (Sun et al., 2018) to identify the university campus's positive or negative orientation and behaviors towards campus-wide sustainability.

In symbolic interactionism, the understanding of the information humans have about their environment as well as the importance they attached to things within their surroundings is also relevant. As such, the study focuses on the preferences that social media stakeholders of the university have for campus-wide sustainability. For instance, individuals are likely to exhibit different behaviors and provide different responses when they are confronted with a questionnaire survey or face-to-face interview and when they are providing comments, opinions, or discussing campus sustainability topics on social media. As such, obtaining data on campus sustainability from both social media and face-to-face interviews with questionnaire surveys might ensure that the overall sustainability behavior is obtained. In studies relating to campus appraisal for sustainability, the vital component of obtaining the importance humans attached to sustainability indicators is the interaction between the individuals and the campuses. Considerations for the perception of the concerned stakeholders and individuals require that they provide a valid basis for constructing and conducting a CSA. It is also paramount for scholars using this philosophical perspective to inquire into the records and history of the individuals or groups being understudied. To ensure that this is considered in the study, the UGC containing (i) Twitter username (ii) Tweet date (iii) Tweet text (iv) number of favorites (v) number of retweets, and (vi) Number of replies were mined.

One of the tenets of symbolic interactionism focuses on the process of interaction among humans rather than the structure of the interaction. When conducting CSA research based on the perspective of symbolic interactionism, understanding the views leading to the decisions, comments, replies, likes that an individual makes about campus sustainability indicators is not enough. The process that led to the comments made by the individuals also needs to be ascertained. Besides, when it comes to understanding humans' behaviors to campus sustainability, it is important to understand the process that led to the action being taken by individuals rather than just focusing on individual behaviors. The adoption of symbolic interactionism based on the computer technology of artificial intelligence in judging the sentiment orientation of the UGC that are related to campus sustainability is also relevant. For instance, the appraisal of the preferences of experts on more than 30 important performance attributes in Andalas University was carried out via the use of AHP (Amrina & Imansuri, 2015). Also, in the process of developing a framework of sustainability assessment for some selected buildings in a

Canadian university and another one in Egypt, a fuzzy TOPSIS approach was used to derive the preferences of some selected experts (Mahmoud et al., 2019).

It should be stated here the findings and conclusions of these previous studies based on their adopted methodologies to arrive at the HEIs stakeholders' preferences are not being undermined or condemned. Nonetheless, the number of stakeholders who participated in the process of reaching the preferred criteria, the objectivity of the methodology, and the advancement of the employed methods seem not impressive.

Society is made up of people who constantly engage in different types of interactions, making it possible for the establishment of human society and campus communities. As such, it makes humans different from other living creatures. Therefore, incorporating the philosophical approach of symbolic interactionism into sustainable campus appraisal would help researchers concentrate and comprehend in more apparent perspectives the studies on societal-based, social media-based, and perspectives of individuals. This is because there will be no HEIs campuses without the interactions of humans. Understanding the meanings attached to campus sustainability across different cultures and societies is important from different societal groups and individuals' views. The adoption of a symbolic interactionism approach to sustainable campus sustainability appraisal has the prospect of widening the knowledge on individual and collective behaviors to campus facilities and infrastructure without neglecting existing theories in the field. Lastly, considerations for the tenets of symbolic interactionism before, during, and after undertaking any campus sustainability appraisal projects could have a massive potential in significantly expanding the knowledge base and development within the field of urban and campus planning.

4.7 Conclusions and Future direction

As a philosophical approach that derived its foundation from the field of sociology, the incorporation of symbolic interactionism in the area of CSA is still missing. Despite several research outcomes of both CSA and the symbolic interactionist perspective, the study of symbolic interactionism as a rational, logical, and analytical concept that incorporates or adopts both sustainable campus and symbolic interactionism is rare. The theory guides in developing efficient, significant, and innovative methods of conducting, discussing, and interpreting campus planning and design for sustainability. On the other hand, it proffers a philosophical as well as a conceptual approach that will ensure that the assessment of the level of environmental sustainability in HEIs is conducted efficiently with the integration of artificial intelligence, social media UGC, machine learning, and sentiment analysis. The theory also ensures that several other technology-driven resources and tools for planning HEIs campuses are incorporated in the campus sustainability studies. For planners, administrators, researchers, and environmental impact assessment experts who utilized several techniques like AHP, environmental impact assessment, and other multi-criteria approaches to appraising sustainable campus, symbolic interactionism offers a theoretical approach to conducting well-structured research contributes to knowledge in the field of urban planning and CSA. The utilization of symbolic interactionism as a theoretical basis for conducting CSA brings into the research area of campus planning and design for sustainability to better understand human sustainability behaviors towards HEIs campuses.

There are some general criticisms of symbolic interactionism in the extant literature. Some scholars maintained that the theory (i) does not apply the scientific method in its approach and cannot comprehensively address the challenges of macro sociology (ii) is mostly limited to the field of sociology and social psychology (iii) the majority of the scholars that are concerned with this theoretical approach only engage in agentic choices that have received a lot of condemnations (Fine, 1993). The theory's criticism from the post-modernism and some other theorists is that its data and collection strategies are perceived as a second-order reality, discursive, and should be dissolved and questioned continuously (Clough, 1989; Schneider, 1991). Blumer responded to some of the critics of this theoretical approach that symbolic interactionism is not a method but rather a philosophical approach (Blumer, 1969). Also, the philosophical approach of symbolic interactionism is not limited to the field of sociology and social psychology, but rather it has been expanded into several other theories like the theories of the development of civilization (Couch, 1984), critical theory, chaos theory (Young, 1991), Parsonian theory. Symbolic interactionism has also been incorporated with cultural studies, and several adoptions of the theories have been identified in extant literature (Fine, 1993). The study perceived the criticisms of the theory as strengths and justification for incorporating this approach in campus appraisal for sustainability because there is a need for modification and continuous review of the HEIs appraisal process.

Future research should utilize sentiment analysis based on the latest machine learning technology to ascertain the identified attributes' orientation (i.e., positive, neutral, or negative). The machine learning technology could also be utilized in understanding the behaviors within HEIs based on the identified campus sustainability attributes. Future studies utilizing the study’s framework and the proposed theoretical basis should be extended to all HEIs in Nigeria and the global south.

4.8 Chapter Summary

A theoretical perspective is vital in categorizing, structuring, and interpreting methodological research findings and explaining campus sustainability studies. A comprehensive review of existing campus sustainability appraisal tools reveals limited utilization and non-specification of theoretical basis in driving campus design and sustainability appraisal. The review also shows the absence of a theoretical basis for guiding the assessment of HEIs' sustainability performance based on social media UGC. In addressing these research gaps, I extensively studied five main social theories that aim at the socialization and challenges of human societies. The outcome led to the adoption of symbolic interactionism as a theoretical basis for campus sustainability. A study was conducted to test the applicability of the theoretical basis in campus planning and design for sustainability in Nigeria, where sustainability in higher education is at a fledgling stage. The result led to identifying localized sustainability attributes and developing an approach that could advance sustainability practices if integrated into existing campus sustainability assessment tools.

CHAPTER 5: ASSESSING THE RELATIVE IMPORTANCE OF SPATIAL-BASED INDICATORS FOR SUSTAINABLE CAMPUS DEVELOPMENT IN NIGERIA HEIs[10]

5.1 Chapter Overview

The appraisal of educational institution campuses' sustainability performance has been on the rise within the past decades. This appraisal is primarily due to the importance of establishing and executing planning policies targeted at designing livable, healthy, and sustainable campuses. In ensuring environmental sustainability for QOL development in Nigerian tertiary institution campuses, allocating relative importance and weights to selected indicators was carried out via the AHP. The relevant indicators peculiar to Nigeria's HEIs were identified based on social media UGC. The AHP involves a pairwise comparison survey with 18 certified town planning professionals from different parts of the country. The study prioritized transportation as the most important sustainability attribute for planning the sustainable campuses of tertiary-level education institutions in Nigeria elsewhere with similar environments. The study adopted a hierarchical structured-based framework from extant CSA tools for AHP and indicators prioritization.

5.2 Introduction

Cities in the developing world are currently experiencing an alarming urbanization growth rate with several cultural, socio-economic, environmental, and health consequences. The rapid urbanization growth rate in the continent of Africa, sub-Saharan African countries, and the West African nations is increasing at an alarming rate. Africa's urbanization rate is projected at 0.96% between 2030 to 2050 (UNDESA, 2012). In Africa, a large percentage of the population lives in cities and other urban centers.

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Many cities in sub-Saharan African countries snowballed in the past decades, with more rapid urban growth projected to take place in these regions. Due to rapid urbanization, the urban growth process outcomes vary worldwide with several complications such as waste management challenges, air pollution, human health issues, and congestion (OECD, 2012). One of the targets of goal 11 of the SDGs is to ensure that the number of cities initiating as well as implementing resources efficiency, resilience to disasters, and climate change adaptation plans and policies increase by 2020 (United Nations General Assembly, 2015).

The current situations demand that cities look for innovative and sustainable ways to mitigate these challenges. Several approaches that have been adopted in combating the challenges facing the cities were mostly technology base. These technologies have been assisting in creating what is generally referred to as sustainable cities. The sustainable/smart city concept offers viable strategies for tackling modern-day city challenges by providing better opportunities for supporting government officials' and policymakers' decisions. According to Albino et al. (2015), sustainable/smart cities' focus during the 1990s was on the importance of modern ICTs concerning the cities' infrastructure. Therefore, the term "smart city" was first used in the 1990s with wide variation among scholars on the specific date. While Mora et al. (2017) opined that the first study on smart cities occurred in 1992, Dameri and Cocchia (2013) stated that the smart city as a concept was first introduced in 1994 with several other divergent views. Based on a bibliometric analysis of smart city research by Mora et al. (2017), it was observed that after the first appearance of the concept of the smart city in the early 1990s, only a few smart city studies were conducted within the first decade. It was during the second decade that the number of smart city studies and the number of smart city publications tremendously increased (De Jong et al., 2015; Durán-sánchez et al., 2017; Mora et al., 2017).

Findings from a comprehensive review of the literature revealed that there are two major schools of thought as to what constitutes a smart city which are: the (i) "techno-centric" proponent and (ii) "human-centric" proponent. The techno-centric group perceives smart cities from [only the ICTs] perspective. In contrast, the human-centric group perceives it from the perspective of the interaction between technology and humans' socio-cultural dimension. The techno-centric group such as IBM, Cisco, Fujitsu, etc., believe that the cities' challenges could be resolved to bring about a smart city via the utilization of ICTs [alone]. On the other hand, the human-centric proponent opined that the use of only ICTs could not bring about a smart city without incorporating the social, cultural as well as local environment into perspective (Mora et al., 2017). The human-centric approach to the smart city in this study is opinion is more appropriate as there are many scholars such as Bakici et al. (2013); Caragliu et al. (2015); Kourtit and Nijkamp (2012) that have defined smart city with reference to human. Therefore, based a comprehensive analysis on several definitions of smart city, the International Telecommunication Union (2014) came up with the most suitable definition of the smart sustainable city as "*an innovative city that uses ICTs and other means to improve quality of life (QOL), the efficiency of urban operation and services and competitiveness, while ensuring that it meets the needs of present and future generations concerning economic, social and environmental aspects*."

Therefore, a city is smart and sustainable when social and human capital investment is incorporated into its ICTs infrastructure. This is when citizens will experience sustainable growth, quality of life, and smart living. Many cities in the western world have adopted the smart city approach (Marsal-Llacuna et al., 2015). According to Lee et al. (2014), an estimated 143 different smart city projects were either completed or ongoing during 2013. Examples include Ottawa's "Smart Capital" project and Quebec City in Canada, as well as the Riverside in California, San Diego, and San Francisco in the USA (Lee et al., 2014). Initiatives and actions related to smart cities exist in several European cities such as Bath, Manchester, Amsterdam, Barcelona, Edinburgh, and Berlin. Two decades ago, Southampton was alleged to be the first smart city in the United Kingdom. In a similar vein, Tallinn, the capital of Estonia, harnessed ICT (Albino et al., 2015), while Seattle city in the USA and Friedrichshafen in Denmark are other examples of cities with several smart city initiatives (Lee et al., 2014). In an attempt to turn one of the most developed countries in Asia into one of the best smart cities in the world, Hong Kong recently developed the Smart City Blueprint (Smart City Consortium, 2016). The Hong Kong smart city blueprint is launched to address the challenges of its cities in an efficient, innovative, and "people-centric" manner based on six major areas. Other nations in Asia that are also striving to achieve the status of the best sustainable smart cities globally are Singapore, United Arab Emirates, Qatar, etc.

Despite the rise in the adoption of sustainable/smart city initiatives, studies, publications, approaches, and implementation since 2009 (Marsal-Llacuna et al., 2015; Mora et al., 2017), it can be observed that the initiation and the adoption of a sustainable smart city that incorporates urban QOL are still lagging in Africa. Several comprehensive studies of literature also established the fact that the contributions from African authors, organizations, and the number of publications on the sustainable smart city are very insignificant as compared to their counterparts from Europe and North America (Mora et al., 2017). Recently, some of the African leaders came together and launched the Smart Africa strategic vision to ensure that the promotion of sustainable development and agenda for social and economic development is achieved via the adoption of ICTs (Smart Africa, n.d.). The smart Africa manifesto also set out five pillars and four enablers to address the continent's significant challenges appropriately. African countries such as Rwanda, Uganda, Kenya, Mali, and Guinea have initiated different sustainable smart cities and ICTs master plan in an attempt to ensure that their countries' development follow the smart Africa strategic vision. However, these sustainable smart cities initiatives are still lagging in Nigeria. To ensure that smart sustainable city initiatives are well incorporated into Nigeria's sustainable development cities scheme, the research and HEIs in Nigeria need to initiate smart city research like that of their counter path in Europe, North America, and Australia.

After a comprehensive literature search on search engines and databases such as Google Scholar, ISI Web of Science, and Scopus databases, I discovered that there is a dearth of studies on sustainable smart cities and QOL from HEIs perspectives in Nigeria. The few studies that have incorporated the concept of sustainable smart cities into university campuses or other higher education campuses have all been carried out in developed countries such as the USA, Italy, United Kingdom, and Germany (Mora et al., 2017). However, no study was identified to have been carried out in Nigeria campuses. It has also been observed that socio-economic and environmental development plans, as well as activities at local, state, regional, and federal government levels, are mostly initiated and manifested at the universities (Boucher et al., 2003; Karatzoglou, 2013; Peer & Stoeglehner, 2013; Sedlacek, 2013). Also, many research findings have unanimously agreed that encouraging and implementing the practices of sustainability at the university level will contribute positively in several ways like minimizing the environmental degradation, waste, and pollution (Adenle & Alshuwaikhat, 2017; Alshuwaikhat et al., 2016; Alshuwaikhat et al., 2017).

In Nigeria, the high level of dependence on non-renewable resources on university campuses due to a lack of sustainability practices has resulted in a high carbon footprint in some universities (Ologun & Wara, 2014). For instance, the supply of electrical energy in the majority of government universities depends on oil to produce enough power for the education sector (Akpama & Okoro, 2012). Involvement in extensive complex activities is another major challenge. The more complex activities a university involves itself and the larger it becomes in terms of land area, the more the requirement for a smart, innovative, and sustainable solution. The majority of universities in Nigeria have involved themselves in several complex activities. Some universities have many campuses in different geographical locations within a state or geopolitical region, while a very large number of them have grown beyond the original master plan guiding the [phase plan] of their campus development. The demand for land, housing, and basic infrastructure (i.e., efficient transportation network) between the university campuses and the adjoining settlement are some of the challenges that have been generating debates and arguments within the last few decades. The level at which these challenges can be resolved depends on the willingness of the heads of institutions and community leaders in resolving these challenges and utilization of sustainable smart spatial innovative techniques. It is evident from the literature that cities that are able to incorporate new technology and a sustainable smart-driven innovative solution are able to resolve their challenges while those that fail to do so experiences more difficulties with no growth.

Unless the smart campus sustainability model and assessment practices are adopted in Nigerian HEIs, most campuses will consume a larger percentage of local oil consumption, and other significant challenges will escalate in the nearest future. The challenges of restricted access to data for an appraisal process will also be eliminated as the indicators will be based on spatial-based, campus-wide, and environmental-dimension that can be spatially retrieved and integrated into the sustainable smart-spatial technique software (Adenle et al., 2020). Therefore, moving toward adopting and developing a sustainable smart framework using GIS and other spatial techniques for campus sustainability has become an urgent need for Nigerian HEIs. Also, the significance and importance of developing a smart spatial-based framework to measure the suitability and sustainability performance of Nigerian HEIs campuses arise from the global axiom of "think globally, act locally" as well as having a country specific-appropriate model that provides a comprehensive information base for government and HEIs administrators. As such, this study seeks to fill this research gap by first determining the level of importance of spatial-based indicators that are aligned with the stakeholders' awareness level and the nature of Nigeria's local context. This alignment will facilitate the development of an approach for sustainable smart HEIs campuses in Nigeria in such a way that the local context of Nigeria will be incorporated toward the achievement of Africa's smart sustainable city agenda.

5.3 Exploring the Weighting Methods for Environmental-related indicators in Existing CSA Tools

Campus-wide and environmental challenges arising from the operations and development of various tertiary institutions over the past decades have made the initiatives and strategies relating to campus sustainability indicators an international concern for campus planners and policymakers. To ensure the elimination of environmental sustainability delay or stoppage, there is a need to allocate relative importance and weights to the selected indicators via weighting methods. As such, assigning relative importance and or weights for CSA domains and indicators is paramount for CSA exercise and research.

The field of campus appraisal for sustainability can be linked to the decision theory that recognized weighting methods (i.e., multi-criteria decision-making) as a significant component of identifying the preferred approaches from several options (Huang et al., 2015). A variety of weighting methods such as multi-attribute utility theory, ANP, TOPSIS, and AHP have been established for assigning values for sustainability attributes in campus planning and related research. The use of these weighting methods can significantly affect the outcomes of effectiveness and accomplishment of CSA (Lukman et al., 2010). These methods also ensure an adjustment of the CSA tools and process by regularly repeating the process or modifying the attributes and or local and international communities involved in the weighting process. Also relevant is the considerable influence the weighting can have on the appraisal tools' statistical significance (Mayer, 2008; Parris & Kates, 2003). The summation of allocated weights to the attributes after completing the weighting methods allows some appraisal tools to develop the sustainability ranking of appraised HEIs (Lukman et al., 2010). Without the allocation of weights and or scores to the selected sustainability indicators, it will be challenging to evaluate, monitor, and compare the advancement that appraised HEIs have attained regarding their environmental sustainability land use planning initiatives, infrastructure management practices, energy conservation, and transportation performance.

Despite the significance of weighting methods in campus appraisal for sustainability, a comprehensive review of the existing CSA tools' weighting methods lags in extant literature. Shriberg (2002) carried out a comprehensive review of 11 existing CSA tools based on the tools' pros and cons of HEI's sustainability performance. Ten years later, 16 tools were reviewed by Yarime & Tanaka (2012) to identify the trends in five areas (i.e., education, governance, operations, outreach, and research) of assessment. Kamal & Asmuss (2013) and Sonetti et al. (2016) also reviewed the existing CSA tools based on their strengths and weaknesses. In 2015, Ceulemans and colleagues conducted a review of the existing tools focusing on the tools' empirical and theoretical approaches (Ceulemans et al., 2015). Also, 12 existing CSA tools were extensively reviewed by Alghamdi et al. (2017) based on their structure, background information, goals, attributes, approaches, and usage. Other studies have been conducted without specific coverage on the utilization of these weighting methods.

In an attempt to fill the existing gaps in the extant literature and then contribute to the better comprehension of the ways to address the challenges of data availability and determination of optimum indicators from amongst multiple options that have been contributing to environmental project failure and delay, this study was conducted. In this chapter, a review of 12 existing CSA tools was carried out from the utilized weighting methods perspectives to justify the adopted weighting method to appraise the relative importance of sustainability for HEIs campuses in Nigeria. This study also seeks to fill this research gap in Nigeria's HEIs by first determining the level of importance of spatial-based indicators that align with the stakeholders' awareness level and the nature of Nigeria's local context. This alignment will facilitate the development of an approach for smart, sustainable HEIs campuses in Nigeria so that the local context of Nigeria will be incorporated toward the achievement of Africa's smart city agenda.

The selection of the extant tools is in line with the selection process utilized in previous chapters. The first consideration is "**within the HEIs context**." Existing sustainability appraisal and reporting tools such as the GRI, the Ecological Footprint, and the Compass of Sustainability that have been utilized by some selected HEIs campuses across the globe for appraisal of sustainability performance and practices were excluded. They were excluded because they are not designed for utilization in HEIs. The HEIs that used these tools experienced difficulties that include but are not limited to non-standardization and the inability to cover sustainability-related issues, especially those specific to HEIs (Lozano, 2006). Another consideration is their "**availability of referenced documents**" (i.e., reports, published articles, manuals, conference proceedings, books, etc.). Existing tools developed explicitly for appraisal of sustainability performance and practices in HEIs, such as the National Wildlife Federation's State of the Campus Environment and Higher Education 21's Sustainability Indicators' are not considered to explore their weighting methods and scoring systems. They are not considered due to their unavailability of referenced documents.

Also considered are the "**tools that utilized indicators approach.**" Due to the level of objectivity, convenient approach to comparing and appraising sustainability performance, and the excellent consistency rate of indicator-based CSA tools, the tools that fall into this category are considered. On the other hand, tools that utilized either the narrative or account approaches were excluded for selection in this study. These tools (i.e., narrative or accounts) are not considered for selection due to justifications that include but are not limited to low their low ratings in transparency and level of consistency (Lozano, 2006). One of the essential components of an appraisal process is a set of sustainability indicators. Various sets of these sustainability indicators are undergoing formulation, selection, and modification in various nations worldwide (Velazquez et al., 2006). The literature review and survey conducted by Velazquez et al. (2006) reveal 23% and 20% of campus sustainability initiatives based on indicators.

5.3.1 CSA Tools Designed by Organizations

In this category, the first HEIs appraisal tool is the **SAQ** developed by the Association of University Leaders for a Sustainable Future between 1999 to 2001. It comprises only one environmental dimension. It does not adopt any ranking benchmarks. It also did not have a fixed weight for assessment nor a category of the final score. However, some of the survey questions request the HEIs representatives to respond by rating their campus sustainability practices. Despite its many limitations, such as completion difficulties for large HEIs campuses, it has been adopted by several HEIs with modifications to the questions when establishing their own SAQ (Alshuwaikhat et al., 2016).

The second is the STARS. The **STARS** was conceived and developed by the Association for the Advancement of Sustainability in Higher Education (AASHE) in collaboration with various HEIs in North America in 2006. It consists of six environmental-dimension indicators (i.e., air and climate; buildings; energy; transportation; waste; and water) with maximum available points of 54. The allotted points are distributed amongst 12 sub-indicators, which are (i) building design, (ii) building energy efficiency, (iii) building operations and maintenance, (iv) campus fleet, (v) construction and demolition waste diversion (vi) greenhouse emissions (vii) clean and renewable energy (viii) commute modal split (ix) hazardous waste management (x) rainwater management (xi) waste minimization and diversion, and (xii) water use. The Air and climate indicators have the highest points of 11 while transportation has the lowest with 7 points. The tool utilized a "Scoring/Rating and Credits/Points System" designed by the tool's developers.

It provides appraised HEIs with an overall score based on accumulated points across the tools categories, subcategories, and indicators. The highest score is 85 with a recognition level of platinum rating, while the minimum score is 25 with a recognition level of bronze rating. However, there is a score with N/A with a recognition level of reporter designation. Other scores are 65 and 45, with a recognition level of gold and silver, respectively. The tool also uses a coin symbol inscribed with the recognition levels to indicate the appraised HEIs level of campus sustainability performance and practices. Although the calculation/procedure with demonstrations for arriving at some of the earned points is provided in the technical manual, some of this procedure is subjective. The developers of the tool can only determine it. The weighting/scoring is only valid for a maximum period of 3 years, although the weighting could be carried out yearly by the registered HEIs. In this tool, the selected indicators' weighting could be optional, required, or not relevant to some HEIs.

5.3.2 CSA Tools Designed by Individuals/Group of Scholars

The **GASU** was designed in 2005 by Rodrigo Lozano with one environmental dimension and six sub-indicators (i.e., material; energy; water; biodiversity; emission, effluent, and water; and transport). The tool utilized a "Worksheet Grading and Weighing System," which was designed by the author. Being a computational tool based on input data, the weights of the indicators are generated after allocating a grading scale of between 0-4. The lowest being zero signifies non-existent, while grade 4, which is the highest grade, signifies an excellent performance of the appraised indicators with a corresponding weight of 100%. Other grades 1, 2, and 3 signify poor, regular, and good performance indicators, respectively, with a corresponding weight of 25%, 50%, and 75%. The level of sustainability performance and practices of the sustainability categories and indicators are presented in chart format. The weights of the categories concerning their contribution to the relevant indicators are performed using three different modalities. The first modality concentrates on core indicators while the second on additional indicators of the tools in arriving at their various weights. The last modality concentrates only on the additional indicators.

Luis Valazquez designed the **SUM** in 2006 with ten environmental-dimension indicators, which are (i) access for handicapped people, (ii) composting, (iii) energy efficiency, (iv) environmental procurement, (v) global climate, (vi) natural waste management (vii) natural heritage (viii) non-hazardous waste management (ix) transportation, and (x) water (Velazquez et al., 2006). Despite the detailed explanation of the importance of indicators in the campus sustainability initiative, the tool did not utilize a scoring method or a weighting method for its adopted strategies and indicators for ensuring sustainability.

Habib Alshuwaikhat and Ismaila Abubakar initiated the UEMS in 2008 with two sets of environmental-dimension indicators (i.e., environmental management and improvement; and green campus) and ten sub-indicators, namely: (i) campus preservation (ii) energy efficiency (iii) environmental improvement (iv) green building (v) green transportation (vi) minimize negative impacts of operations (vii) pollution (viii) recycling (ix) resources conservation (x) waste reduction. However, there is no weighting/scoring method for the selected indicators.

The **TUR** was developed by Lukman and colleagues of the Department of Chemistry and Chemical Engineering, University of Maribor, Slovenia, in 2010. It tool has an environmental dimension but lacks indicators that comprehensively represent the environmental performance of HEIs. The tool utilized AHP to weigh the selected indicators to determine each weight of the indicators and their important impacts on the tool’s appraisal process's numerical outcomes. In determining the weights and relative importance of the selected indicators, 40 pairwise comparison questionnaires were sent out to different experts worldwide, and 16 responses were received from experts from nations from the Scandinavians, United Kingdom, and North America. The outcome of the survey shows a consistency index of 0.0046 based on equation (5.1), where I_C is the consistency index, λ_{max} represents the calculated eigenvalue with a value of 3.0092, while N is the order of the judgment matrix.

$$I_C = \frac{\lambda_{max} - N}{\mathrm{N-1}} \tag{5.1}$$

On the other hand, a consistency ratio of 0.008 was obtained based on the equation (5.2), where R_C is the consistency ratio, I_C remains as the consistency index, and the values of R_I are provided by Saaty, the developer of the AHP technique-(See Table 5.1).

Size	1	2	3	4	5	6	7	8	9	10
R_I	0.00	0.00	0.52	0.89	0.11	1.25	1.35	1.40	1.45	1.49

Table 5. 1: Values of R1

The values of the final priorities were obtained via the aggregation of each indicator's priorities based on equation (5.3), where $w(C_{ij})_{Bj}$ represents the local priority weight of C_i with respect to B_j, and $w(C_{ij})_A$ represents the local priority weight of indicator *i* in a group *j* concerning A.

$$R_C = \frac{I_C}{R_I} \tag{5.2}$$

$$w(C_{ij})_A = \sum_{ij}^{N}[w(C_{ij})_{Bj} w(B_j)_A] \tag{5.3}$$

For normalization of the ranges between the data, equations (5.4) and (5.5) were utilized to standardize the outcome values. Here, $C^+_{N,ij}$ in equation (5.4) represents "more is better" and $C^-_{N,ij}$ in equation (5.5) represents "less is better."

$$C^+_{N,ij} = \frac{C^+_{ij} - C^+_{min,j}}{C^+_{max,j} - C^+_{min,j}} \tag{5.4}$$

$$C^-_{N,ij} = 1 - \frac{C^-_{ij} - C^-_{min,j}}{C^-_{max,j} - C^-_{min,j}} \tag{5.5}$$

Aggregation was carried out using the equation (5.6) and (5.7)

$$B_j = \sum_{ij}^{N} w\left(C_{ij}\right)_{B_j} C_{N,ij}^{+} + \sum_{ij}^{N} w\left(C_{ij}\right)_{B_j} C_{N,ij}^{-} \tag{5.6}$$

$$\sum_{ij}^{N} w\left(C_{ij}\right)_{B_j} = 1, w_{ji} \geq 0 \tag{5.7}$$

Finally, equation (5.8) represents the basis for the overall ranking of appraised HEIs where $w\left(B_j\right)_A$ signifies aspect concerning the weight assigned to group *j* within an Index A

$$\mathrm{A} = \sum_{j}^{N} w\left(B_j\right)_A B_j = \sum_{ij}^{N} w\left(C_{ij}\right)_A C_{ij} \tag{5.8}$$

The **AMAS** was designed by Francisco Urquiza Gomez and his team in 2014 with one environmental-dimension sub-criteria (i.e., resource consumption) and five indicators, which are (i) energy consumption, (ii) energy efficiency measures, (iii) hazardous waste management (iv) water consumption, and (v) water efficiency measures. Like TUR, the AMAS tool also utilized AHP to establish the relative importance of the selected indicators. Unlike the TUR that had 16 pair-wise comparison responses, AMAS received 23 valid survey responses from experts in different countries in Europe and North America after sending out 112 surveys to international experts worldwide. After that, eight responses were received from experts in Chile for the weighting of local indicators. Like TUR, equations (5.1) and (5.2) above were used to arrive at the consistency index and consistency ratio. The overall weight of the various levels of the indicators was aggregated using equation (5.9).

$$w(I_k)_A = w(B_i)_A \sum_{ij}^{N} [w(I_k)_{C_j} w(C_j)_{B_i}] \tag{5.9}$$

Where $w(I_k)_A$ represent the overall weight of the model fourth level (I_k) containing 25 indicators in relation with the first level, which is the overall goal (A) of actualizing campus sustainability. $w(B_i)_A$ represent the weight of the model second level (B_i) containing three criteria in relation with the first level, which is the overall goal (A) of actualizing campus sustainability. $w(C_j)_{B_i}$ represents the aggregated weight of the tool's third level (C_j) containing nine sub-criteria concerning second level criterion (B_i). Finally, $w(I_k)_{C_j}$ represents the weight of the fourth level indicator (I_k) but this time with respect to the third level sub-criterion (C_j).

In ensuring that the differences in the unit of measurement of the selected indicators and the variation or volume of data for the appraisal process are effectively aggregated, a normalization approach based on equations (5.10) and (5.11) is utilized.

$$I_{N,k}^{+} = \frac{I_k - I_{min,k}}{I_{max,k} - I_{min,k}} \tag{5.10}$$

$$I_{N,k}^{-} = \frac{I_{max,k} - I_k}{I_{max,k} - I_{min,k}} \tag{5.11}$$

In equations 5.10 and 5.11, the minimum and maximum outcomes of the indicator k are represented by $I_{min,k}$ and $I_{max,k}$ respectively while the value (i.e., higher value equals better and lower value equals best) of the normalization process for indicator k is represented with both $I_{N,k}^{+}$ and $I_{N,k}^{-}$. However, the final outcomes after the normalization process are accomplished via the utilization of the equations (5.12), (5.13), and (5.14), in which (C_j) and (B_i) represents the performance for the sub-criteria j and criterion i, respectively. In equation c, A represents the overall score of the appraised HEIs.

$$C_j = \sum_{jk}^{n} w(I_k)_{C_j} I_{N,k}^{+} + \sum_{jk}^{n} w(I_k)_{C_j} I_{N,k}^{-} \tag{5.12}$$

$$B_i = \sum_{jk}^{n} w(C_j)_{B_i} C_j \tag{5.13}$$

$$A = \sum_{k}^{n} w(I_k)_A I_{N,k}^{+} + \sum_{jk}^{n} w(I_k)_A I_{N,k}^{-} \tag{5.14}$$

The results show that the resource consumption with 0.5025 is highly ranked compared to the remaining eight sub-criteria, while the indicator (i.e., recycling program coverage) is amongst the three indicators with higher relative importance.

Bushra Waheed and colleagues of the Memorial University, St John's, Canada, proposed the **D-SiM** in 2011 with five "environment" categories, each under the linkage-based framework of DPSEEA (driving force, pressure, state, exposure, and effects) with 22 indicators. These indicators are [(i) annual energy consumption rate; (ii) amount of energy used; (iii) amount of water supplied and distributed/collected for purification; (iv) concentration of greenhouse gases; (v) concentration of emissions, effluents, and waste; (vi) changes in environmental conditions; (vii) effects on biodiversity; (viii) effects on environment; (ix) effects on human health; (x) exceedance of noise level; (xi) increasing transport density (xii) impact on energy resources; (xiii) percentage daily commute by motor vehicle and transport conflicts; (xiv) proportion of people exposed to poor air conditions; (xv) proportion of people exposed to poor water quality (xvi) proportion of people exposed to various hazards; (xvii) proportion of people exposed to high noise levels, (xviii) production of greenhouse gases (xix) production and consumption of ozone-depleting substances (xx) production of emission, effluents, and waste; (xxi) rate of depletion of energy resources; (xxii) rate of water consumption and quality]. However, the three environmental indicators (i.e., effects on biodiversity, effects on environment, and effects on human health) underneath the tool's DPSEEA framework's effect stage were utilized in the estimation of the tool index.

A multi-criteria decision-making technique known as "simple weighted average" is utilized for the quantitative appraisal of the selected environmental-dimension indicators due to its simplicity and ability to acknowledge tradeoffs that exist amongst the selected indicators. In this tool, the weights were allocated to the selected indicators with values ranging from 0-1. Here, 0.0 represents "no" value, 0.10 represents "extremely low", 0.25 represents "very low", 0.45 represent "low", 0.5 represents "medium", 0.65 represents "high", 0.75 represents "very high", 0.90 represents "extremely high", and finally, 1.00 stands for "absolute" value. These weights are determined based on either the positive or negative impacts of the selected indicators on the sustainability level. Equation (5.15) is used for the estimation of dependent indicators.

$$A_j = \frac{[w_1 X_1 + w_2 X_2 \ldots + w_n X_n]}{(w_1 + w_2 \ldots + w_n)} \tag{5.15}$$

Where A_j represents estimated activation level of a dependent indicator j, w_i represents the weight allocated to the indicator I, and X is the "predefined/predetermined" activation values of supporting indicators. In quantitatively aggregating the HEIs sustainability index for the determination of HEIs rankings after the appraisal process, the equation (5.16) is utilized where SI represents Sustainability

Index, A_{env} is the activation level of environment effect, which is the focus of this article while A_{econ}, $A_{soc,}$ and A_{edu} represent the level of economic, social, and education, respectively.

$$SI = \frac{[A_{env}\, w_{env} + A_{econ}\, w_{econ} + A_{soc}\, w_{soc} + A_{edu} w_{edu}]}{(w_{env} + w_{eco} + w_{soc} + w_{edu})} \quad (5.16)$$

In ensuring normalization of the SI outcomes, equation (5.17) is proposed by the authors.

$$SI_N = \frac{(SI - 0.10)}{(0.34)} \quad (5.17)$$

5.3.3 Justifications for the Adoption of AHP in CSA

The review of the existing CSA tools reveals several justifications for the utilization of AHP in determining the relative importance of sustainable indicators. AHP was utilized in AMAS to overcome the challenges of satisfactory accuracy in determining the weights of indicators that are accompanied by complicated phenomena and difficulties in objective comparison.

The AHP was utilized by (Lukman et al., 2010) to ensure flexibility and inclusion of additional indicators to their proposed model via the repetition of their pairwise comparison questionnaire. Studies show that the utilization of AHP by most policymakers is as a result of its adoption by scholars and stakeholders for the decision-making process in extant literature (Jato-Espino et al., 2014). AHP has the potential of assisting campus planners, decision-makers, and policymakers, and developers of CSA tools in exploring multiple campus sustainability indicators simultaneously before arriving at their appropriate relative importance, weights, and scores. Nonetheless, due to other weightings, grading, and scoring methods utilized by some of the reviewed existing CSA tools, as shown in **Table 5.2**, the adoption of AHP within the context of HEIs for campus planning, design, and appraisal for sustainability demands for justification.

Selected Extant Sustainability Assessment Tools	**Weighting Methods**
SAQ	-

GASU	Worksheet Grading & Weighting System
SUM	-
UEMS	-
AISHE 2.0	-
USAT	-
TUR	AHP
D-SiM	Simple Weighted Average
Graz	-
SCAS	-
AMAS	AHP
UI's GreenMetric	-
STARS	Scoring/Rating & Credit/Point System

Table 5. 2: Weighting Methods of the Selected Extant CSA Tools

A brief discussion of some of these justifications are provided as follows:

First, the use of a small sample size. A review of the extant literature reveals that the acceptance and the usage of AHP were strongly related to its ability to utilize a small sample size of experts for a pair-wise comparison survey. Unlike other approaches that demand huge statistically considerable sample sizes to produce reliable and statistically significant outcomes, a small sample size is sufficient for robust results with the use of AHP (Doloi, 2008). The ability of AHP in concentrating on the precise and specified task provided room for the use of a small sample size (Lam & Zhao, 1998). Since the process of arriving at indicators' relative importance with the use of AHP is expert-based, opinions of selected few experts in a field can sufficiently become representative (Abudayyeh et al., 2007; Tavares et al., 2008). The adoption of AHP in a study involving a large sample size can invalidate the research outcomes because experts who do not have well-grounded knowledge within the specific project area might provide an inconsistent and unsupported response (Cheng & Li, 2002). Despite its use of a small sample size, there exist in literature variations regarding the optimum sample size. While the sample size in some articles is less than 10 (Akadiri et al., 2013; Chou et al., 2013), a small proportion of the review articles utilized sample sizes of above 20 (Ali & Al, 2009; Monir et al., 2009). These indicate that with a small sample size, AHP outcomes can be successfully implemented in resolving indicators preferences challenges in the HEIs. However, decision-makers utilizing this method still need to consider other options carefully before finalizing the option of AHP.

Second, a review of extant literature shows that a decent amount of scholars that have adopted the AHP have done so due to its high level of consistency (Ã et al., 2008; Abudayyeh et al., 2007). AHP has a higher rate of eliminating biases and checking that the selected experts' personal opinions are authenticated via consistency analysis (Saaty, 1987; Vargas, 1982). This ability of AHP in terms of a high level of consistency, a combination of objective and subjective information to arrive at the optimum decision has made it become a paramount tool in the hands of decision-makers in the environment and construction-related field. As such, when conducting studies that involve experts with different opinions and levels of experience, the utilization of AHP will assist in ensuring that a high level of consistency is attained.

Another justification is its simplicity and the ability to determine weights and level of importance of indicators using easily operated computerized tools. With AHP, easy-to-use computerized tools such as Microsoft Excel, PriEst, and Expert Choice software can be used to facilitate the analysis in ensuring a numerical appraisal of each proposed scenario (Ã et al., 2008; El-anwar et al., 2010). With the adoption of AHP, there is simplicity and ease of dissecting the challenges of the HEIs campuses design, planning, and assessment for sustainability practices and performance into a hierarchy. This breakdown into hierarchy ensures better comprehension of included variables and categories, and pairwise comparison can be easily carried out. This way, the need for special software skills for the complex mathematical procedure that is involved and a complex structural approach to arriving at an optimum solution is eliminated.

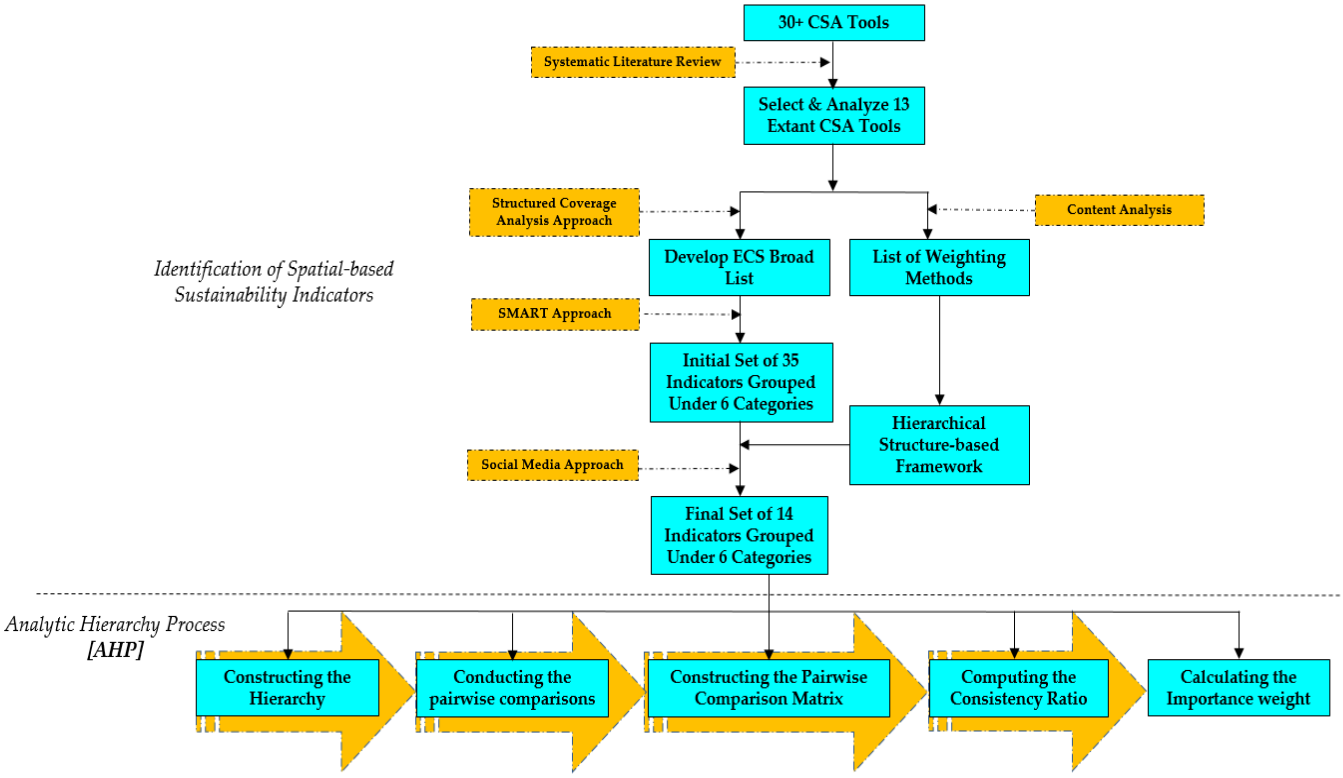
Lastly, continuous monitoring and review of the appraisal process. The pair-wise comparison survey with the selected qualified professionals can be conducted on a regular basis to allow for the inclusion or removal of sustainability attributes to reflect the current need and nature of HEIs sustainability performance and practices. The selected experts involved in the pair-wise comparison survey can also be modified to ensure that the outcomes of the weighting process are carried out by the qualified members of the society. Gomez et al. (2015) perceived appraisal tools that do not incorporate a process that ensures the removal or addition of sustainability attributes when needed as rigid and insensitive to adaptability.

5.4 Methodology

A framework of spatial software such as GIS using campus-wide indicators to examine the practices and performance of sustainability in HEIs campuses that affect QOL and livability is one way to ensure smart, sustainable campus planning and appraisal. This section presents the methodology utilized in identifying the selected spatial-dimension sustainability attributes and their respective relative importance for campus-wide planning and assessment.

The adopted methodology for this study comprises several stages depicted in **Figure 5.1**. First, identifying the (i) list of weighting methods and (ii) ECS Broad list after content and structured coverage analysis of extant tools for sustainability assessment in HEIs. This weighting methods identification and developed ECS Broad list were followed by (a) hierarchical structure-based framework and (b) identifying spatial-based campus sustainability attributes with more significant awareness/preferences by social media users concerning the peculiarities of HEIs in Nigeria. After that, the authors determined the relative importance of the identified indicators via weighting that involves assigning greater or lesser value to the indicators. A spatial-based infrastructure model was proposed to ensure that the sustainable smart city concept is appropriately integrated into the framework of CSA using the identified spatial-based attributes.

Figure 5. 1: Study Research Approach



When developing a spatial data infrastructure for planning and appraising HEIs campuses for smart sustainability and QOL attainment, it is important to involve stakeholders' local priorities. Unlike other CSA tools that mainly rely on a few experts in localizing the indicators' relevance or priorities, this study utilized stakeholders' social media UGC. It is also paramount for the scholars or developers to identify the relative importance of the sustainability categories and the indicators before designing a smart campus spatial data infrastructure to prevent delay or stoppage before or during the implementation stage.

5.4.1 Identification of the Spatial-based Sustainable Indicators

Indicators are context-dependent embedded with normative characters and affect the administrative decision-making process (Krank & Wallbaum, 2013). Indicator systems are usually designed to foster rationality in decision-making and give insight into campus sustainability by collecting information about key sustainability aspects. Thus, indicators must be clearly defined, and their selection criteria should also be transparent and participatory. When properly designed and utilized, indicators can offer valued information for reducing resource usage in unnecessary information generation. The relevance of sustainability indicators is usually determined through experts' opinion surveys, case studies that analyze existing indicator programs, or criteria-based theoretical analyses (Krank & Wallbaum, 2013). The indicator selection process adopted in this study is presented in the next sub-sections.

5.4.1.1 S^{2}MART (Spatial-dimension, Specific, Measurable, Achievable, Relevant, Time-specific) Filtering Process Approach

In this study, the first step in identifying the sustainability indicators was reviewing 13 existing campus-based appraisal frameworks. The existing tools were selected for extracting a comprehensive list of indicators as a starting point due to their (i) availability in English as well as in the published article, report, and technical report format (ii) appraisal based on different levels of indicators (iii) establishment being focus on institutions of higher education. **Table 5.3** contains the selected extant tools with their corresponding sustainability attributes.

Selected Extant Sustainability Assessment Tools	Total Attributes
Sustainability Assessment Questionnaire	7
Graphical Assessment of Sustainability in University	71
Sustainable University Model	27
University Environmental Management System	34

Assessment Instrument for Sustainability in Higher Education	35
Unit-based Sustainability Assessment Tool	9
Three dimension University Ranking	18
DPSEEA-Sustainability index Model	81
Graz Model for Integrative Development	20
Sustainable Campus Assessment System	63
Adaptable Model for Assessing Sustainability in Higher Education	37
UI's GreenMetric University Sustainability Ranking	45
Sustainability Tracking Assessment and Rating System	94
Total	**541**

Table 5. 3: Overview of the 13 Campus Sustainability Appraisal Frameworks

After extracting the 541 attributes (i.e., 486 indicators within 55 categories) from across the 13 existing CSA frameworks, the stage that follows ensures that all attributes were subjected to the S^2MART filtering process. The approach ensures that the selected indicators are analytically sound and can effectively appraise Nigeria's sustainability performance.

The filtering process outcomes based on the S^2MART method are highlighted as follows: **Spatial-dimension**: The filtering process that limits the comprehensive list of attributes to spatial-dimension attributes reduces the overall attributes to 115 indicators in 13 categories. After that, attributes that appear more than once or with similar meaning were merged to ascertain, specifically sustainable spatial-dimension attributes leading to 9 categories and 81 indicators. This stage led to spatial-dimension attributes that are too generic and complex for sustainability appraisal. Also, all remaining attributes could not be measured and were not relevant to the Nigerian HEIs context leading to the continuation with the other attributes of the S^2MART Approach. **Specific**: At this stage, 24 indicators were too generic and therefore filtered out from the list limiting only the indicators to 60. **Measurable**: The remaining attributes' measurability characteristics led to 6 categories and 38 indicators at this stage. **Achievable**: Here, all the indicators were perceived to be feasible, and no reduction was carried out at this stage. **Relevant**: After filtering by the relevance nature of the attributes, there were six categories and 35 indicators. **Time-specific**: At this stage, all the remaining indicators have the characteristic of a time frame in which any observable change could be calibrated.

After ensuring that potential indicators have satisfied the S^2MART attributes, the step that followed was selecting the indicators to be included in the framework based on the filtering process within Twitter Social Media data from 142 Nigerian universities' official accounts. This Twitter Social Media data filtering was carried out to ensure that people-centric smart, sustainable campus design based on the people's needs and awareness level within the study's national context is achieved.

5.4.1.2 Social Media Filtering Process Approach

In literature, there are two general approaches for selecting sustainability indicators (Reed et., 2006). (a) a top-down approach where a group of experts first defines both the framework and the indicator set, after which decision-makers and communities make minor modifications to meet local conditions where necessary. This top-down approach often yields a set of more standardized and scientifically valid tag indicators, even though community priorities might be excluded. (b) the bottom-up approach, a more participatory approach where decision-makers, community opinion leaders, and other stakeholders first define and select the indicators and assessment framework, some experts will review and finalize. This method tends to reflect community priorities more than the top-down Approach, although coverage of sustainability issues may be partial.

This study utilized the participatory approach based on the reliance on disclosed campus-based information on Twitter social media (reflecting university community priorities) after evaluating the S^2MART criteria. Unlike the traditional participatory process involving town hall meetings, interviews, and surveys embedded with several challenges and limitations, such as substantial financial costs and difficulties, stakeholders' and participants' inability to express opinions and views fully. These challenges are eliminated on social media platforms (Sun et al., 2018) because the stakeholders can express their opinion and contribute in their convenient environment without intimidation, fear, compulsion, and inclusion of bias. From amongst the close to 3 billion active social media users, Twitter social media platform has around 300 million engaging members (with Nigeria boasting of approximately 6 million daily end-users), releasing around half a million tweets daily in different parts of the world. The utilization of this technology-driven and participatory approach of stakeholders to identify preferred sustainability indicators is also in line with some SDGs targets that raised concern on information, technology, and telecommunication.

In actualizing the purpose of the participatory approach in indicator selections based on Twitter social media, data of stakeholders of HEIs in Nigeria are obtained based on (i) data from Twitter (ii) content filtration

(i) **Data from Twitter**: The study first utilized Logstash to mine UGC from the official Twitter account of 142 Nigerian universities. (Logstash is one of the three internet-based tools for analyzing different types of big data from sources. The remaining two are called Elasticsearch and Kibana, and they are jointly known as Elastic Stack). After that, a Python 3 library (GetOldTweets3 0.0.11) was used to extract more than half a million UGC from the 142 Nigerian universities' official Twitter account in comma-separated values (CSV) format. The mining via the Python 3 library was successfully carried out after specific command lines within some detailed timeline were inputted. The timeline was stated as the day each official Twitter account was created and limited to December 31, 2019.

Another series of command lines was later performed to ensure that the UGC transfer in CSV file format is converted to a new line JavaScript Object Notation (nlJSON) layout. The mined UGC conversion from CSV to nlJSON was done to actualize the appropriate configuration during data filtering, cleaning, and analysis. Logstash was, after that, utilized in piping the extracted UGC into Elasticsearch to ensure the data are appropriately filtered/cleaned and Kibana for the actualization of data analysis.

(ii) **Content Filtration**: The approach adopted at this study stage identifies UGC that contains the environmental-based sustainability indicators identified at the end of the S²MART Approach. The final filtering/selection process ensures that only the targeted indicators' UGC was carried out on the Elasticsearch interface (i.e., Elastic Stack 7.5.0 version). The social media filtering outcome led to spatial-based sustainability indicators of six categories and 14 indicators in **Figure 5.2**.

5.4.2 Determination of Identified Indicators Level of Importance

5.4.2.1 Analytic Hierarchy Process

The process of assigning significant weight adopted in this study is known as the AHP. It was utilized to identify the spatial-dimension sustainability attributes relative importance and weight. AHP is required in city development (Lee & Chan, 2008), campus planning, and sustainability appraisal because the tasks involved are sensitive. The outcomes might have repercussions on the people's QOL and livability within the campuses and the environment in totality. As such, the utilization of AHP for integrated appraisal concerning sustainable campus development is paramount.

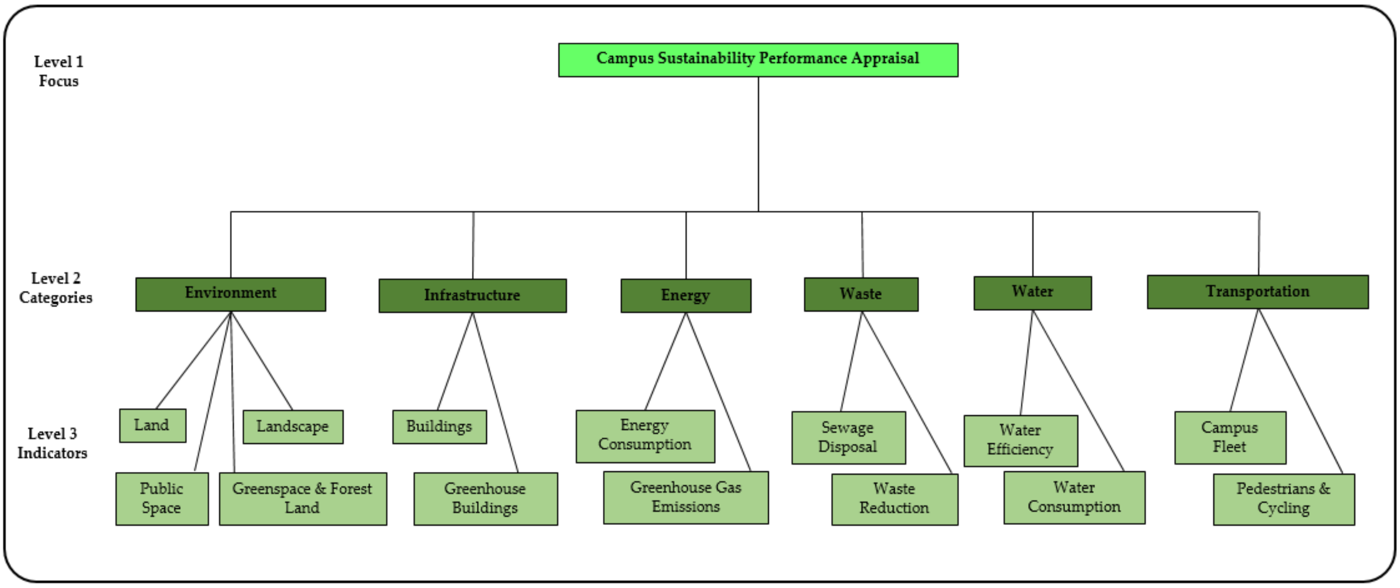
The challenges of resolving the multifaceted, complicated, complex, and multivariable projects led to the establishment of the AHP in 1980 by an Architect known as Thomas L. Saaty. AHP aids in arriving at the selections that are symbolized by multiple connections, linkages, and mostly competing for variables, and it provides preferences from amongst the decision variables. The most crucial part is that the variables to be considered for final decisions are appraised in considerations to the level of importance to ensure an adjustment between them.

AHP has been used in campus sustainability studies (Li et al., 2018; Sanchez et al., 2018; Wiganingrum et al., 2018); however, none of the existing studies utilized the indicators selection process adopted in this study. Also, this study adopted the technique of AHP due to its several strengths. First, its ability to schematically reveal the challenges being resolved. Second is the method simplification of the pairwise comparison for experts and faster application. Another is the small sample size and a higher level of consistency among experts' judgments. Finally, its versatility makes it an excellent choice for making strategic and sound campus appraisal decisions. However, there exist criticism of AHP in extant literature such as (i) inconsistencies introduced by the method's 1-9 scale, (ii) transformation of the oral process of comparison to numerical scale, (iii) reversal of the indicator relative importance with addition/removal of indicators (Barfod & Leleur, 2014).

In this study, five stages were involved in conducting the level of importance and weightage via AHP, which are (i) hierarchy formulation, (ii) pairwise comparisons, (iii) pairwise comparison matrix, (iv) verification of consistency, and (v) important weight calculation. They are as follows:

i. **Formulating the Hierarchy**: This stage entails constructing three-level hierarchies based on the identified spatial-based, environmental campus sustainability indicators. The top level is the overall goal, followed by the categories level and the last level that consists of the indicators. At level 1, the task's overall goal is to appraise Nigerian HEIs campuses' sustainability performance level. Level 2 comprises the six categories (i.e., energy, environment, infrastructure, transportation, waste, and water) of the sustainability indicators, and level 3 consists of all the 14 indicators that describe every single category. **Figure 5.2** illustrates the hierarchical structure.

Figure 5. 2: Hierarchy for the preference of appraisal indicators for campus performance



ii. **Pairwise Comparisons:** After the 3-level hierarchy formulation, a pairwise comparison was carried out to calculate each spatial-based campus sustainability indicators' weight. The pairwise comparison survey was adopted because of a more straightforward and effective comparison rather than a simultaneous comparison between six categories. The pairwise comparison between the categories and the six categories' indicators was carried based on Saaty's nine-point scale (see **Table 5.4**) (Saaty, 1987).

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Neither of the two alternatives is preferable over the other
3	Moderate importance of one over another	One alternative is preferred slightly over the other
5	Essential or strong importance	One alternative is preferred clearly over the other
7	Very strong importance	One alternative is preferred very strongly over the other
9	Extremely importance	One alternative is preferred very strongly over the other

2,4,6,8	Intermediate values between the two adjacent judgment	Can be used for graduation between evaluation
Reciprocals of above	If activities i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A comparison mandated by choosing the smaller element as the unit to estimate the larger one as a multiple of that unit

Table 5. 4: Pair-wise Comparisons Underlying Scale

iii. **Pairwise Comparison Matrix**: The geometric mean method was utilized to retrieve the weights of the experts' responses after constructing the pairwise comparison matrix. The overall weight of the various levels of the indicators concerning the categories and level one was aggregated using equation 5.18.

$$w(C_{ij})_A = \sum_{ij}^{N}[w(C_{ij})_{Bj} w(B_j)_A] \tag{5.18}$$

Where $w(C_{ij})_{Bj}$ represent the weight of the hierarchy third level (containing 14 indicators) concerning the second level (containing six categories). $w(C_{ij})_A$ is calculated concerning the overall goal (A) of actualizing campus sustainability.

iv. **Important Weight Calculation:** The spatial-based sustainability indicators' relative weight was computed based on the presented results.

v. **Consistency Ratio**: As a result of the subjective nature of AHP, there is the need for the optimization of the results via the process known as the verification of the consistency. However, this consistency verification involves a consistency ratio calculation. The consistency of a study's judgment that utilized AHP can be guaranteed only if the consistency ratio's outcome is not more than 0.1 (Saaty, 1987). If the consistency ratio is more than 0.1, a need for revision will be required before prioritizing the study's categories, and indicators can be concluded.

5.5 Results and Discussion

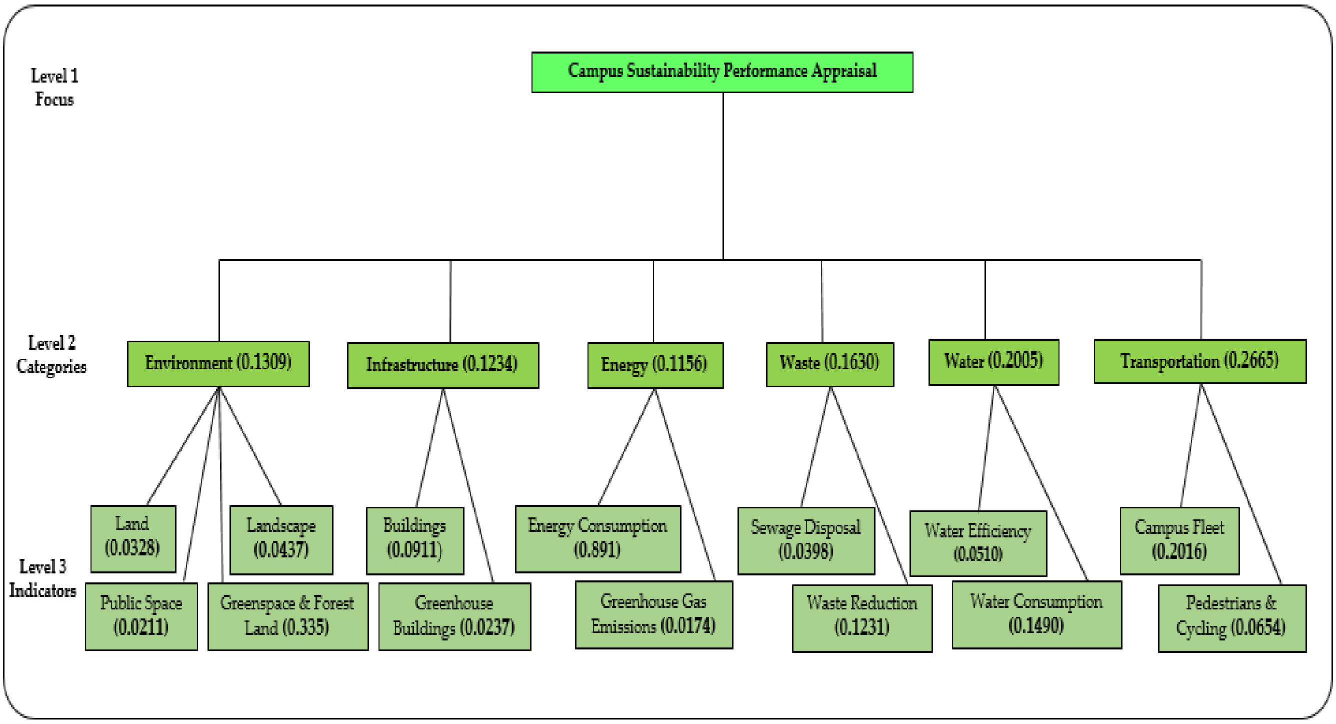
5.5.1 Results of the AHP

The identified spatial-based campus sustainability indicators for sustainable campus appraisal for Nigerian HEIs were then validated by experts registered members of the Association of Town Planning Consultants of Nigeria (ATOPCON). ATOPCON is an umbrella body that consists of all the registered urban planning firms in Nigeria. The association was established during the last two decades, with more than 50 registered Town planning firms and organizations. Each registered Town Planning firm is registered and certified for carrying out spatial development practice and consultant by the Nigerian Institute of Town Planners (NITP) and the Town Planners Registration Council (TOPREC). Since the registered firms in Nigeria are responsible for the planning and executing physical planning, policies, and programs that include the campuses of HEIs, obtaining the experts' subjective judgment seems to be perfect for this study. Before the commencement of the AHP, experts within the firms that have carried out designing, planning, campus feasibility and impact analysis, environmental impact assessment, etc., were consulted for validation of the spatial-based indicators to Nigeria HEIs. They all validate that the identified indicators with their categories reflect the nature of Nigerian HEIs. After that, the authors applied the AHP technique to assess the relative importance and allocation of the verified indicators' appropriate weight.

A total of 18 experts from amongst the 120 registered town planning firms with the ATOPCON were consulted to express their subjective judgments of the relative importance of the identified sustainability indicators. The 18 experts were selected to ensure that the experts' preferences served as the country's representative. Although there are 36 states and a Federal Capital Territory (FCT) in Nigeria, the 120 firms were only situated in 17 states and the FCT. One expert from each of the firms across the 17 states and the FCT was identified for consultation.

Based on the steps of the AHP discussed in the methodology section, the relative importance weight of the spatial-based sustainability indicators is calculated, and the results are depicted in **Figure 5.3**. Transportation, with a value of 0.2665, received the highest level of importance. One reason for this might be the absence of high capacity parking space and the lack of multiple transportation modes to ease mobility challenges on most campuses. Energy received the least weight with 0.1156. although outcomes of some past studies reveal high dependence of HEIs campuses in Nigeria on non-renewable resources in electrical power (Ologun & Wara, 2014; Akpama & Okoro, 2012). Unlike other government institutions, I am not surprised because most HEIs in Nigeria experience an uninterrupted electricity supply.

Figure 5. 3: The Relative Importance of Weight



After the consistency ratio computation was carried out in this study, none of the values were more than 0.1. The consistency ratio was obtained based on **equation 5.19**, where R_C is the consistency ratio, the values of R_I are provided by Saaty, the developer of the AHP technique, and I_C as the consistency index. The consistency index is calculated based on **equation 5.20** where λ_{max} represents the calculated eigenvalue with a value of 3.0092, while N is the order of the judgment matrix.

$$R_C = \frac{I_C}{R_I} \tag{5.19}$$

$$I_C = \frac{\lambda_{max} - N}{\mathrm{N}-1} \tag{5.20}$$

This value shows that the experts' assigned relative importance is consistent, and the indicators can be used to assess sustainability practices within Nigeria HEIs campuses.

5.5.2 Spatial Data Infrastructure Framework for Nigeria HEIs Campuses

The selection and identification of spatial-based campus sustainability indicators for sustainable smart and quality campus-wide sustainability appraisals have been discussed in the previous sections. This section will present the discussion on spatial software/techniques such as GIS and Building Information Modelling (BIM) integration into sustainability appraisal for HEIs campuses in Nigeria. The utilization of spatial techniques results from studies of existing smart city concepts from across the globe and the ability and the capacity of these spatial data infrastructure platforms to integrate massive amounts of geospatial data. For instance, in the Hong Kong Smart City Blueprint (Smart City Consortium, 2016), from 2018, the city planned the adoption of BIM during the implementation of essential construction projects by the Hong Kong Special Administrative Region (SAR) government. The blueprint also seeks to develop a spatial data-based portal for distributing digital maps, geospatial information, etc., between different government agencies. Regarding addressing the challenges of data accessibility, the city advocates for using open data to achieve smart city innovations and strategies and initiatives for smart city infrastructure.

The utilization of these spatial-techniques-based indicators model in Nigeria HEIs campuses will improve sustainability performance in various dimensions. With transportation being the attribute with the highest level of importance, the spatial data infrastructure framework integration with CSA could be used for campus walkability evaluation to retrieve, assess, and share traffic and pedestrian routes information. This walkability evaluation will assist in reducing several needless transportation challenges and allow for more efficient smart mobility. With the continuous rise in the number of established HEIs campuses across the country, some practitioners have regarded these campuses as CenterPoint of different sustainability challenges. Nonetheless, the implementation of this proposed framework might lead to a paradigm shift in the educational system.

5.6 Conclusions and Recommendations

QOL and livability cover a relevant topic for appraisal in ensuring the sustainable development of HEIs campuses. The continuous dismay with QOL and environmental-dimension challenges led to innovative development and implementation in different parts of the world. This innovative approach is known as smart sustainable cities. Its relevance covers areas such as quality environment, healthy living, and vibrant community with various transportation and other land use options and CSA. Several CSA frameworks have been designed to measure the environmental performance of a variety of HEIs. These frameworks also support the decision-making process either to the whole campuses or for specific phases. Although a wide variety of sustainability rating systems can be adopted for HEIs in Nigeria, locational variation has prevented any of these tools in Nigeria, which necessitated this study. With complex infrastructure, massive resource consumption, and waste generation, most higher education campuses can generate consequential environmental impacts. Therefore, it is paramount to conduct a sustainability appraisal of the performance level of these institutions. In this study, the authors identified a set of spatial-based and environmental-dimension indicators peculiar to the nature of Nigeria campuses for establishing a CSA process. The indicators were first extracted from 13 existing frameworks after a comprehensive literature review followed an elimination process via the S^{2}MART Approach. After that, the indicators were filtered based on Twitter social media UGC in Nigeria to identify only the indicators that reflect Nigeria's campus environmental sustainability situations. The AHP methodology was subsequently utilized to determine the indicators’ level of importance.

The challenges of assessing university campuses' environmental sustainability in developing countries include the absence of or difficulties in obtaining useful campus-wide attributes; integrating spatial data infrastructure into indicator frameworks could help minimize these challenges. The proposal's limitation consists of remote sensing, the Internet of Things, fifth-generation (5G) mobile networks, and computer skills required to build the system. These technologies and skillsets could be lacking in some HEIs within Nigeria, requiring the financial requirement to install the portals and infrastructure and workforce skill training. Future research on CSA using the proposed spatial data infrastructure framework is needed to test its applicability. There is a need for sentiment analysis via any selected machine learning software to ascertain the campus sustainability behavior of the key HEIs stakeholders in Nigeria. Lastly, to increase the number of relevant stakeholders in future studies, there is a need to expand social media UGC sources to unofficial Twitter accounts and UGC associated with all the HEIs in Nigeria.

CHAPTER 6: MODIFIABLE CAMPUS-WIDE APPRAISAL MODEL (MOCAM) FOR SUSTAINABILITY IN HEIs[11]

6.1 Chapter Overview

The fundamental differences amongst the CSA tools are the approaches in which the sustainability categories, indicators, and sub-indicators are conceptualized, the connections between the various attributes, the approach and methodology utilized in grouping/merging the identified challenges, and the selection/aggregation of attributes weights/scores are carried out. Currently, there is an absence of a CSA tool that is ideal for campus sustainability performance and practice appraisal. The existing tools are all designed in such a way that they do not have the capacity to address the multitude of sustainability challenges across various campuses in different regions across the globe. Therefore, this chapter proposed an overall framework for appraising campus-wide sustainability in HEIs in Nigeria.

6.2 Introduction

The 1972 Stockholm Conference was amongst the first international approach toward sustainability in which strategies to prevent the challenges confronting the existence of humans were initiated (de Paula Arruda Filho & Przybylowicz Beuter, 2020). Thereafter, in 1987, the most widely accepted and used definition of sustainable development as "*the need of the present generation without compromising the ability of the future generation to meet their needs*" was contained in the Brundtland Report (Brundtland Commission, 1987). However, several approaches such as that of the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1997) in ensuring sustainable development actualization have been proposed. A decade for the initiation, incorporation, and execution of education for sustainable development was also announced by the United Nations (UN) (UNESCO,

[11] This chapter is partially published in:
Adenle, Yusuf A., Chan, E. H. W., Sun, Y., & Chau, C. K. (2020). Modifiable Campus-wide Appraisal Model (MOCAM) for Sustainability in Higher Education Institutions. *Sustainability*, *8* (2020), 1–17. https://www.mdpi.com/2071-1050/12/17/6821

1997). This UN declaration mandates HEIs to adopt the concept of sustainability in their operations, teaching, research, and appraisal.

The establishment of a sustainable society can be enhanced with the involvement of HEIs in awareness creation, knowledge dissemination, and skills acquisition (Cortese, 2003). More so, that they (i.e., HEIs) nurture and train future generations through teaching, academics, research, and management and community engagement programs that will aid their designing, planning, and implementing the development of sustainable human societies. Lukman and his colleague posited that the actualization of a sustainable global village is achievable via effective publicity of sustainability practices by the HEIs (Lukman et al., 2010). Also, HEIs students can easily implement sustainability practices in society by experiencing these practices within their HEIs campuses before graduating (Cortese, 2003). As such, the implementation of sustainability initiatives, programs, and plans encompassing all-around activities and operational functions should be carried out by HEIs.

In the global context, declarations such as the Barcelona and Talloires can be attributed as foundations in realizing the state of affairs for sustainability performance appraisal at HEIs. In addition to these international declarations, CSA tools also assist in achieving the actualization of sustainability undertaking and higher QOL attainment (de Matos Pedro et al., 2020) in HEIs. Several reviews of the various CSA tools have been conducted in extant literature (Alghamdi et al., 2017; Ceulemans et al., 2015; Kamal & Asmuss, 2013; Shriberg, 2004; Sonetti et al., 2016; Yarime & Tanaka, 2012). The reviews reveal that with the several declarations, UN mandates, and establishment of numerous CSA tools, limitations and knowledge gaps that demand the attention of scholars, practitioners, and policymakers in campus planning and appraisal still exist. Alshuwaikhat and colleagues observed the lack of spatial-dimension of HEIs campuses into the framework of existing CSA (Alshuwaikhat et al., 2017a). Likewise, the exploration of social media coverage practices in CSA tools has not been extensively covered despite social media's ability to disseminate and monitor sustainability indicators.

Though social media in campus-related articles have been widely examined and discussed, social media research is still in its infancy. Another challenge confronting researchers conducting CSA is the formulation of a theoretical basis that serves as the foundation for organizing and illustrating the relationship between HEIs CSA and the identification of preferred campus sustainability indicators based on social media data. Detailed explanations, theoretical framework, or philosophical approach concerning this challenge is paramount to ensure considerable ground for conducting CSA. It has also been established for a long time that to achieve some milestones or targets; there is a need for measurement as the foundation for such targets. This concept has found its way into CSA as well (Shriberg, 2002b). The yield of any practice to introduce the concept of sustainability in academic campuses will become substantiated with a philosophical basis and HEIs stakeholders' indicators preference/localization toward sustainable campus before assessing how much the academic organization has been able to achieve the desired results.

Currently, HEIs in Nigeria are one of the least ranked globally, with few HEIs among the HEIs that are recognized in the world universities ranking. However, the increase in the number of public and private HEIs is one of the fastest in Africa due to the country's large population and high rate of urbanization. The population of students, teaching, and non-teaching staff is projected to continue to be on the increase in the next decades. Other challenges that include but are not limited to an inefficient campus transportation system, pollution, urban sprawl, lack of campus basic facilities and infrastructure, dysfunctional campus land uses, degradation of the campus environment, and unsustainable campus production and consumption pattern are also affecting various campuses. The desire to resolve these challenges is revealed in the 2009 Abuja Declaration (held in Nigeria) on sustainability in African higher education (AAU, 2009). The declaration participants acknowledge that sufficient attention to conducting, disseminating, or implementing sustainability research and practice lacks in Africa HEIs. Therefore, the declaration encourages the HEIs in Africa to reassess their education system in terms of sustainable development and conduct campus sustainability performance assessment. Also, there is an absence of sustainability accounting information on the official websites of two Nigerian universities that are signatories to the Talloires Declaration (Khan, 2013).

Although Nigeria has been investing in the planning and development of its HEIs, there is a considerable gap in the development of tools, techniques, frameworks, or metrics to measure the sustainability performance of these institutions. Evaluation and effectiveness appraisal reports of the already existing campus development policies are not available on the official websites of various designated departments. A review of the literature indicates a lack of research, data, and non-availability of official statistics on campus sustainability in Nigeria. These findings show that sustainability practices and reporting in Nigerian HEIs are primarily neglected, and it is expected that campus sustainability performance is deficient. In short, the status of campus sustainability is unknown in Nigeria. For instance, despite the inclusion of a Nigerian private university amongst 1004 registered HEIs to utilize the Sustainability Tracking, Assessment, and Rating System (STARS) tool as of mid-2020, the university has neither participated in the appraisal process nor received a sustainability performance rating. This sustainability rating status might be because STARS was initially created for North American HEIs, not sub-Saharan African countries. The challenge of data restriction due to financial demand on the part of the participating institutions could be another justification for the unknown state of their sustainability status (Gomez et al., 2015).

Taking into account the lack of measurement and data on such an important issue means there is a real need to examine the sustainability performance of Nigerian campuses. Most importantly, there is the need for the development of an adaptive localized model to assess the campus-wide impacts of the HEIs campuses on QOL as well as to establish some appropriate policy recommendations for authorities concerning campus sustainability. In addressing these challenges, this chapter aims to develop a Modifiable Campus-wide Appraisal Model (MOCAM) for the sustainability of HEIs in Nigeria and other sub-Saharan African countries with un-known sustainability rankings. The development of this model is timely and critical as there is presently non-availability of such a campus model performing these activities within the Nigerian and sub-Saharan African countries context.

6.3 Comparing Existing CSA Tools

During the developmental stages of the proposed appraisal model, the following criteria were utilized in selecting the existing CSA tools for content analysis and coverage evaluation. They are (i) indicator-based, (ii) English Language-based, (iii) HEIs focus-based, and (iv) document-based. A brief description of the selection criteria is provided below.

Firstly, Indicator-based. Although there exist in extant literature different approaches to appraising sustainability practices in HEIs, I adopted the indicator-based approach to develop the proposed model and assess sustainability performance. This adoption is in line with other scholars that prioritized indicator-based assessment over other approaches due to its better performance level, objectivity, measurability, and ease in outcome comparison (Lozano, 2006). As such, several CSA tools with appropriate and excellent appraisal procedures but designed with narrative or account assessment were excluded.

Secondly, English Language-based. Also, several CSA tools are developed in non-English speaking countries or by non-English speaking developers; I only utilized tools whose content information is written in the English language. This selection is also in compliance with the selection criteria of researchers that have previously conducted CSA tools reviews (Alghamdi et al., 2017). The tools such as the German Commission for UNESCO, Conference of Rectors of Spanish Universities, and the tool developed in Colombia were excluded.

Thirdly, HEIs Focus-based. Under this criterion, only tools that are designed specifically for the appraisal of sustainability practices, reporting, and ranking in HEIs are considered for selection. Assessment tools such as the GRI that is mainly utilized in appraising sustainability performance in corporate organizations, although adaptable for HEIs, were excluded.

Lastly, document-based. Lastly, the selected tools must be available in documents format such as technical manuals, reports, articles, etc., to allow for content evaluation, extraction of sustainability indicators, and referencing. Tools such as Benchmarking Indicators Questions – Alternative University Appraisal (BIQ-AUA) and the Green Plan were excluded from the selected CSA tools due to the authors' inability to retrieve their document for reference.

At the end of this selection process, 13 existing CSA tools were selected, as contained in **Table 6.1**. To comprehend the differences that exist in the selected tools and gain an understanding of their adoption, applicability, and approach in addressing the gaps observed in the literature, the following four criteria were used as a basis for comparison. They are: (i) weighting method (ii) theory/framework utilized (iii) social media platform utilized (iv) environmental-dimension with campus-wide, and spatial-based (ECS) sustainability attributes utilized (see **Table 6.1**). A brief discussion of the comparison criteria and the need for their utilization in such a comparison is provided below.

Weighting Methods: Campus planning and development decision-making involve procedures that entail selecting the best options from among multi variables. The process of arriving at these best alternatives by decision-makers during campus-wide planning or environmental challenges mitigation is hugely associated with a myriad of setbacks in the real world. In the field of decision theory, the weighting method represents one of the paramount pillars and is mostly utilized in discerning the optimum approach from multiple alternatives (Huang et al., 2015). Since introducing these methodological approaches, several techniques have been initiated to advance the field of decision theory and the weighting method. Examples of these methods include but are not limited to simple multi-attribute rating technique, Analytic network process (ANP), Technique for the Order of Prioritization by Similarity to Ideal Solution (TOPSIS), ratio estimation in magnitudes or deci-bells to rate alternatives which are non-dominated (REMBRANDT) and analytic hierarchy process (AHP) (Saaty, 1987). Solutions to decision-making challenges in urban development and the built environment projects involving campus design and planning are mostly attained via the use of these approaches.

Therefore, the need for the comparison of the selected existing tools based on the weighting method.

Theory/Framework Utilized: In the fields of urban planning and social sciences, research from a theoretical perspective is unquestionably a paramount one. A more significant percentage of great scholars known in these fields are theoretical scholars. However, within the last decade, many planners and social scientists are now giving less attention to theory development, utilization, and studies based on quantitative research methods have become dominant. Some of the consequences of not adopting or incorporating a theoretical basis in CSA studies include but are not limited to (a) an inability to accumulate knowledge, (b) lack of persistency, (c) inability to differentiate different events, and (d) utilization of the wrong methodology. It is also imperative for researchers that are using more than one method to identify and rectify all the various theoretical approaches before commencing on a CSA project/model development. In the field of campus planning, a theoretical approach that will assist in interpreting and organizing the development and utilization of an appraisal model is required to ensure that the field is advanced in a scholarly manner. To fill the identified research gap, this criterion was utilized in comparing the existing tools.

Social Media Platform Utilized: The recent rapid expansion that is currently witnessed within the field of HEIs planning, campus master plans, and the considerable interest of many researchers in campus sustainability audit and appraisal requires the need for adoption and the incorporation of social media data, machine learning, deep learning, sentiment analysis, and artificial intelligence. During the first quarter of 2019, more than 3 billion people were reported as active social media users in different parts of the world, with over 2 billion users operating all kinds of media activities on their mobile devices (Hasnat et al., 2019). Recently, green campus and sustainable campus initiatives have been trending on social media with a massive amount of UGC that could be utilized in comprehending the campus sustainability indicators with local context preferences. Based on this development, utilizing and advancing the accuracy, volume, and precision analysis of social media data is a welcome idea. This utilization is an opportunity to contribute to knowledge and close the research gap in campus sustainability and development in developing countries if a massive amount of data from various social media platforms is utilized. In this study, Mangold and his colleague's social media classification was utilized to compare the social media platforms utilization for indicators selection, data empirical validation, or case studies (Mangold & Faulds, 2009).

ECS Sustainability Attributes Utilized: This criterion compares the inclusion of ECS campus sustainability attributes in existing CSA tools to determine how integrating GIS and or other spatial techniques into the indicator-based framework for campus sustainability could ameliorate the challenges of data availability and accessibility for CSA in developing countries. The provision of spatial-dimension, guidelines, and spatial techniques are paramount because the adoption level of issues explicitly stated in the guidelines is higher than the implicit issues (Urbanski & Filho, 2015). Most campuses of HEIs have a large campus area with different transportation modes, facilities, and infrastructure covering large areas of land and several spatial-based campus attributes. As such the need for this criterion for comparison.

CSA Tool	Weighting Method	Theory/Framework	Social Media	ECS-based Attribute		
				Category	Indicator	Sub-indicator
SAQ	-	-	-	1	-	-
GASU	-	-	-	1	1	6
SUM	-	(i) General Systems Theory (ii) Benchmarking Process (iii) The Plan-Do-Check-Act (PDCA) Cycle	-	1	10	-
UEMS	-	-	-	1	2	10
AISHE 2.0	-	(i) EFQM Excellence model (ii) The PDCA Cycle	-	1	2	-
USAT	-	-	-	-	1	-
TUR	AHP	-	Wikipedia	1	-	-

DPSEEA	-	Linkage-based Frameworks	-	-	5	22
Graz	-	-	Facebook	-	-	-
SCAS	-	-	-	1	11	10
AMAS	AHP	-	-	-	1	5
Green Metric	-	Three E's Framework: Environment, Economics, Equity & Education	-	5	11	-
STARS	-	-	(i) Facebook (ii) Twitter (ii) Interactive blog	1	6	12

Table 6. 1: Comparison of the Selected Appraisal Tools

Though **Table 6.1** presents the summary of the comparison between the existing CSA tools, the content analysis and the coverage evaluation of the selected tools reveal the following:

In terms of the weighting methods, their utilization can influence the sustainability performance appraisal report, result visualization, comparison, or ranking of HEIs campuses after undergoing the appraisal process by various tools (Lukman et al., 2010). The review and comparison show non-utilization/specification or justification for the selected weighted methods in most of the tools. The weighting method gives room for monitoring, reviewing, and enhancing the CSA tools via regular repetition of the pair-wise comparison by experts. This flexibility shows that most of the existing tools are rigid and lack flexibility/adaptability for use in a different context. Assessment tools are rigid when there is no weight assignment procedure and difficulties in adding or removing indicators (Gómez et al., 2015). However, TUR and AMAS utilized AHP allowing for flexibility and indicators addition and removal.

Regarding the theory/framework utilized, a review of extant literature reveals that sustainability is a complex process. This complexity has led to disruption in assessing the sustainability of academic campuses due to their diverse nature. This problem can be overcome by providing the campus administrators with an assessment model, a standard gauge against which the performance can be monitored and evaluated, and a theoretical basis that gives a general explanation of the process. Like all other models, the tools for CSA must possess a specific philosophical basis to streamline the assessment process. The comparison shows that most of the tools were driven by the limitations of the existing tools and the availability of sustainability indicators for HEIs. However, a general system theory was utilized that delineates the important elements for comprehending various aspects or components of HEIs (Velazquez et al., 2006). Also utilized by two of the existing tools is the PDCA cycle, also known as the Deming cycle, based on the principle of regular advancement effort to allow for incremental progress over a long period (AISHE 2.0 Manual, 2009; Velazquez et al., 2006). A quality management model and framework that ensures the connection between individual aspects to identify an efficient approach to address the impacts of indicators (AISHE 2.0 Manual, 2009; Waheed et al., 2011). In summary, none of the tools used main social theories to review the sustainability concept continuously. They would have driven their approach in utilizing social media data despite the boom of social media during the development stage of these tools.

This study also advances existing studies by reviewing and analyzing social media and social data coverage in existing CSA tools. The results reveal that despite the presence of indicators that seeks to appraise HEIs sustainability performance on communication, public participation, student involvement, etc., in most of the tools, social media platforms as means of achieving this sustainability performance were neither mentioned nor utilized in most of the tools. Social media usage was limited in the existing tools. This limitation is despite developing some of these tools in developed countries where different social media platforms are utilized. These findings are inconsistent with studies that show a strong correlation between social media usage and improvement in HEIs campuses' sustainability activities (Zachos & Anagnostopoulos, 2018). Lastly, the outcomes reveal an absence of

ECS indicators in some of the tools and variations in their usage and selection. It was observed that these variations could lead to the difficulties of arriving at uniform appraisal ratings of several campuses. Therefore, the need for a model for appraising different campuses across the geographic or local context with localization of the indicators to the relevance of each campus. This comparison reveals that tremendous improvement can be adopted, utilized, or modified to fill the gaps identified in the literature in terms of lack of or restricted access to data, choosing a set of indicators, as well as difficulties in indicators appraisal. These challenges could be minimized by integrating the GIS and or other Spatial Software into the CSA spatial-based Model.

In addressing the challenges of HEIs campus sustainability in Nigeria with considerations to the gaps identified in the existing ranking, rating, and appraisal tools, the next section describes the proposed appraisal framework.

6.4 Constructing the Appraisal Model

This section may be divided into subheadings. It should provide a concise and precise description of the experimental results, their interpretation, and the experimental conclusions that can be drawn.

In developing an appraisal model with campus-wide and spatial-based indicators that apply to different HEIs within the context of Nigeria and, by extension, other HEIs in sub-Saharan African countries, the sequential stages depicted in **Figure 6.1** were utilized. A brief description of these stages are provided as follows:

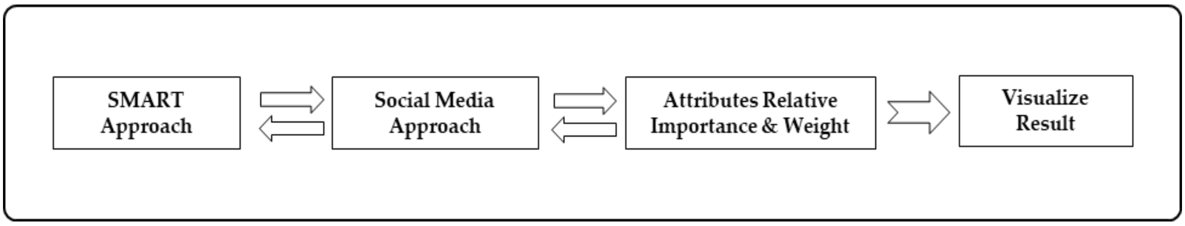
SMART Approach: The SMART (specific, measurable, achievable, relevant, and time-bound) approach is a goal attainment approach that has been used utilized in previous campus and management studies (Alshuwaikhat et al., 2017b; Shahin & Mahbod, 2007). In this study, the approach was used to extensively explore the indicators (such as the striking balance between breadth of coverage and inclusion of indicators) in addition to the coverage evaluation approach.

Social Media Approach: This allows for calibrating the CSA categories and indicators based on local context to ensure the selection that corresponds to the needs and nature of HEIs in Nigeria. This approach is achieved by calibrating the indicators with SMART attributes with the social media UGC relating to campus sustainability awareness, engagement, knowledge, etc., of HEIs stakeholders.

Attributes Relative Importance and Weights: Amongst the various techniques of weighting methods, AHP, which was designed by Saaty (Saaty, 1987), is the most highly used and has gained a high level of awareness in the building, planning, and construction industries as well as the sustainable campus appraisal research area. Decision-making challenges in the area of designing, planning, and developing of HEIs campuses involve a lot of complexity, complications, and uncertainties (Chan et al., 2009). As such, making a concise and best decision in solving developmental projects in the area of the built environment is a necessity that should not be overlooked. Therefore, the choice of AHP in identifying relative importance and weights of selected attributes are due to several reasons such as (i) ability to make better and strategic built environment-related projects decisions (Jato-espino et al., 2014) (ii) higher level of consistency (iii) selection of a perfect and most favorable option from amongst several alternatives during multiple criteria decision process, and (iv) simplified communication using an index to display overall ranking of an institution.

Visualize Result: To allow for communication and comparison of the appraisal results that is conceivable by all HEIs stakeholders, the appraisal outcome of the proposed model will be a spatial, graphic support that aid visual examination of the HEIs campus. GIS, BIM, CityEngine, and or other related spatial tools are important in the campus-wide appraisal of HEIs campus; however, their usage is currently lagging in the existing CSA tools.

Figure 6. 1: Roadmap to Campus-wide Sustainability Appraisal



6.4.1 Identification and Verification of Attributes Reflecting and Match the Nature of HEIs in Nigeria

6.4.1.1 SMART Approach

The inclusion of measurable sustainability indicators based on value judgment has been extensively studied and supported in extant literature (Shields et al., 2002), although the selected sustainability indicators for the appraisal process are recommended to be conducted within the context of objective principles. As such, the process of identifying indicators for sustainability performance models/projects should be carried out in a systematic, transparent, and most importantly, participatory manner. In this study, while ensuring that the selected indicators can effectively apprise campus-wide sustainability performance with analytically sound outcomes, the selection process entails: first, the identification and extraction of a comprehensive list of indicators from the existing 13 CSA tools. Therefore, the environmental-dimension indicators with spatial-based and campus-wide attributes were selected to form an ECS broad list. This selection was followed by a filtering process based on the SMART approach (Alshuwaikhat et al., 2017b; Shahin & Mahbod, 2007). The SMART approach ensures that the indicators selected for the CSA process possess the attributes briefly described below:

Specific: The selected indicators should be stated unambiguously. They should clearly define the aspect of the campus-wide, and environmental-dimension outcomes of the appraisal will be derived. They should be specified conceivably by HEIs stakeholders. Measurable: The selected indicators should possess a standardized unit of measurement to allow for comparison and statistical analysis obtained from the numerical values selected. Achievable: The selected indicators should possess the attributes that will ensure the attainment of overall appraise goals, objectives, outcomes, and deliverables. Relevant: The selected indicators should have the capacity of attaining the local demands and the sustainability challenges of the institutions within the geographical region of the appraisal exercise. Time-bound: The selected indicators allow for periodic audits and continuous monitoring and review. The indicators that do not meet these 5 SMART attributes were excluded from the sustainability performance of campus-wide sustainability.

6.4.1.2 Social Media Approach

The preferences of key or concerned stakeholders on challenges affecting HEIs can be referred to as the public's perception of the aspects of the sustainability activities on these campuses. It can also be referred to as the comments, assessment, evaluation, reactions, or sentiment of experts on campus conditions, resources, management practices, and sustainability indicators. It provides relevant contributions to the development of appraisal tools that incorporate the desires and direction of the end-users. These stakeholders' preferences can positively or negatively affect the campuses in aspects that include but are not limited to (i) winning of funds and grants, (ii) attraction of sponsors, investors, and students (iii) sustainability appraisal rating and ranking.

The determination of the preferences of concerned HEIs stakeholders can the obtained through the satisfaction level of these stakeholders in terms of sustainability behaviors, awareness of campus sustainability activities, and similar topics. The need to consider critical stakeholders' awareness level and satisfaction in management, operations, urban/campus setting and infrastructure, environment, and transportation necessitate the carrying out of stakeholders' preference. Literature review reveals that target group interviews, small group questionnaire surveys, important performance analysis, fuzzy TOPSIS, analytic hierarchy process (AHP), expert opinion, and scoring constitute the significant approaches of appraising stakeholders' preferences in HEIs studies. In these methods, only a few key stakeholders are involved in designing, planning, and developing HEIs. In the AMAS (Gomez et al., 2015) CSA tool, eight local experts were consulted in identifying indicators with local priorities.

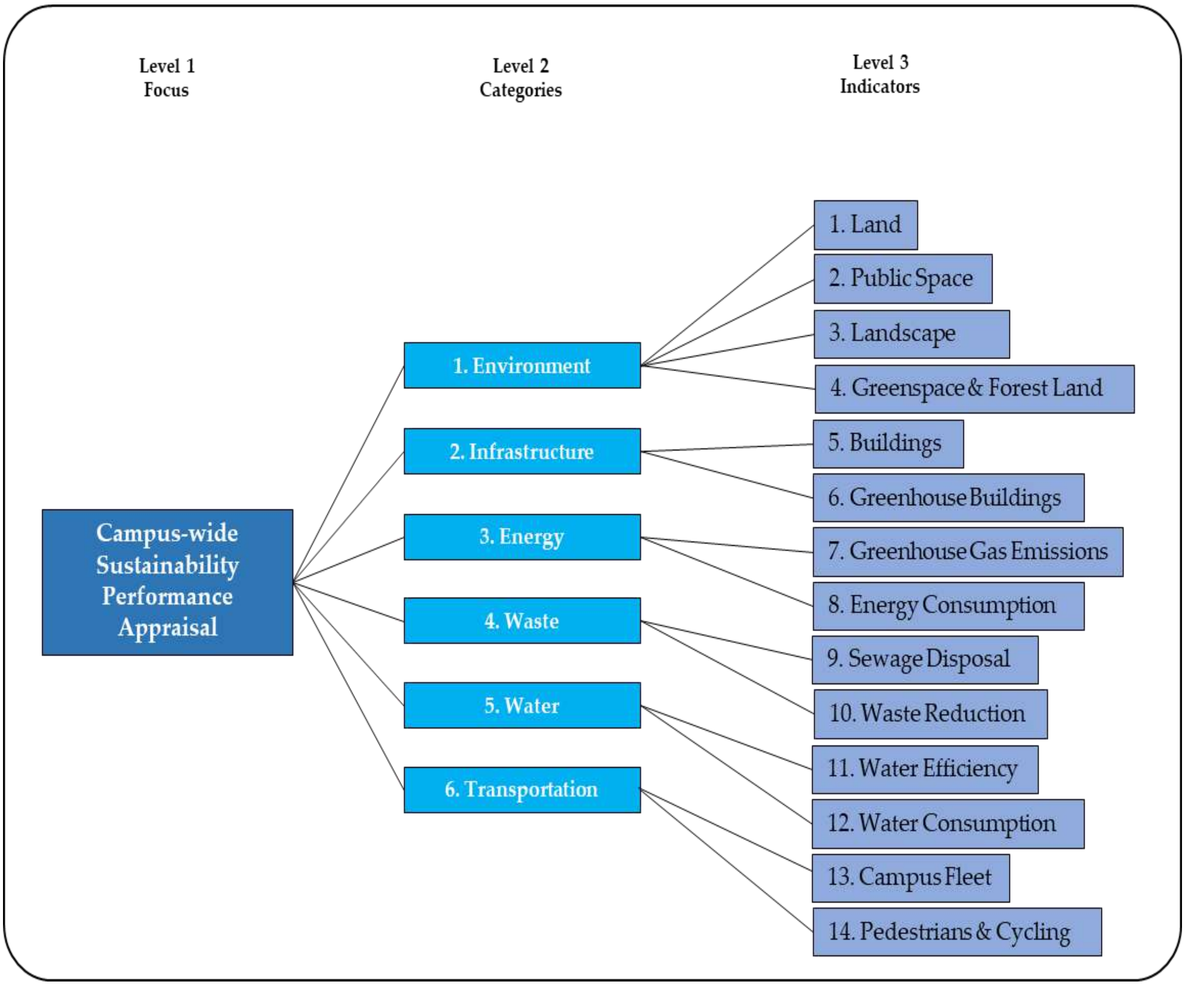
This study utilized a novel approach involving the UGC from the Twitter social media platform of official accounts of all universities in Nigeria to incorporate local priorities. The UGC was mined using Python Library, while Elastic Stack was used to filter, analyze, and identify only indicators that appeared in the UGC based on the campus sustainability awareness level of HEIs stakeholders in Nigeria.

6.4.2 Determination of CSA Attributes Relative Importance and Weights

In this study, AHP was utilized in determining the localized attribute level of importance and their corresponding weights. In understanding the usage of AHP with spatial techniques, a comprehensive review of existing literature reveals the connection between AHP and spatial-based information systems. An integrated approach that combined AHP with NetWeaver and spatial-based software was designed in Spain (Ruiz et al., 2012). While the AHP was used to determine weights for the spatial-based indicators, the spatial-based software (ArcGIS) was utilized to store and perform a particular spatial analysis. Ahmad and teammates also utilized another spatial-based software with AHP, utility theory, and an online analytical process to select and rate selected variables' level of importance (Ahmad et al., 2004). They also ensure that a case study of how the integrated approach has been successfully applied was presented to reveal the reliability and validity of their approach.

Again, it was discovered that AHP was either utilized in addition to other theoretical approaches and methodology in ensuring a better outcome or as an independent method. This better outcome assurance shows that the incorporation and or the adoption of AHP in the field of campus planning, development, and assessment to ascertain the level of importance of variables is a welcome development. Although other weighting methods such as TOPSIS, REMBRANDT, and ANP produce reliable decision-making outcomes, AHP has a distinctive edge over them because they are more complicated, challenging, and protracted (Jato-espino et al., 2014). After completing the social media approach of environmental-dimension indicators with campus-wide and spatial-based attributes identification, experts with urban planning, designing, impact appraisal, etc., knowledge and skills registered with the Association of Town Planning Consultants of Nigeria (ATOPCON) were consulted for validation. This consultation was followed by developing a 3 level hierarchy (**Figure 6.2**) with the overall goal of campus-wide sustainability performance appraisal on the first level, followed by six categories levels and with 14 indicators applicable within the context of HEIs campuses in Nigeria.

Figure 6. 2: Appraisal Hierarchy for the Relative Importance



A pair-wise comparison survey based on Saaty's nine-point scale was carried out with 18 registered Town planners across the six geopolitical zones of Nigeria. The pair-wise comparison survey allows for the transformation of verbal judgment to numeral values by ensuring the appropriation of weights to spatial-base sustainability categories and indicators. The outcomes reveal satisfying consistency ratios. Individual weight was aggregated to attain the overall weights of the categories and indicators concerning the overall focus of campus-wide sustainability performance appraisal based on **equation 6.1** below.

$$\mathrm{w}(C_{ij})_A = \sum_{ij}^{N} [\mathrm{w}(C_{ij})_{Bj}\ \mathrm{w}(B_j)_A] \tag{6.1}$$

$w(C_{ij})_A$ is the weight of the indicator C_{ij} with respect to the overall focus, which is the campus-wide sustainability performance appraisal. $w(C_{ij})_{Bj}$ is the local priority (weight) of C_{ij} in relation to Bj. However, $w(B_j)_A$ the local priority (weight) of indicator i in a group j in relation to A (Saaty, 1987).

To aid the dissemination of the outcomes, a spatial-based technique (i.e., GIS, BIM, etc.) could be utilized in visualizing the performance of the spatial-based and campus-wide indicators. Campus-wide comparison based on the environmental dimensions could also be appraised using this spatial software.

6.5 Modifiable Campus-wide Appraisal Model (MOCAM) for Sustainability in HEIs

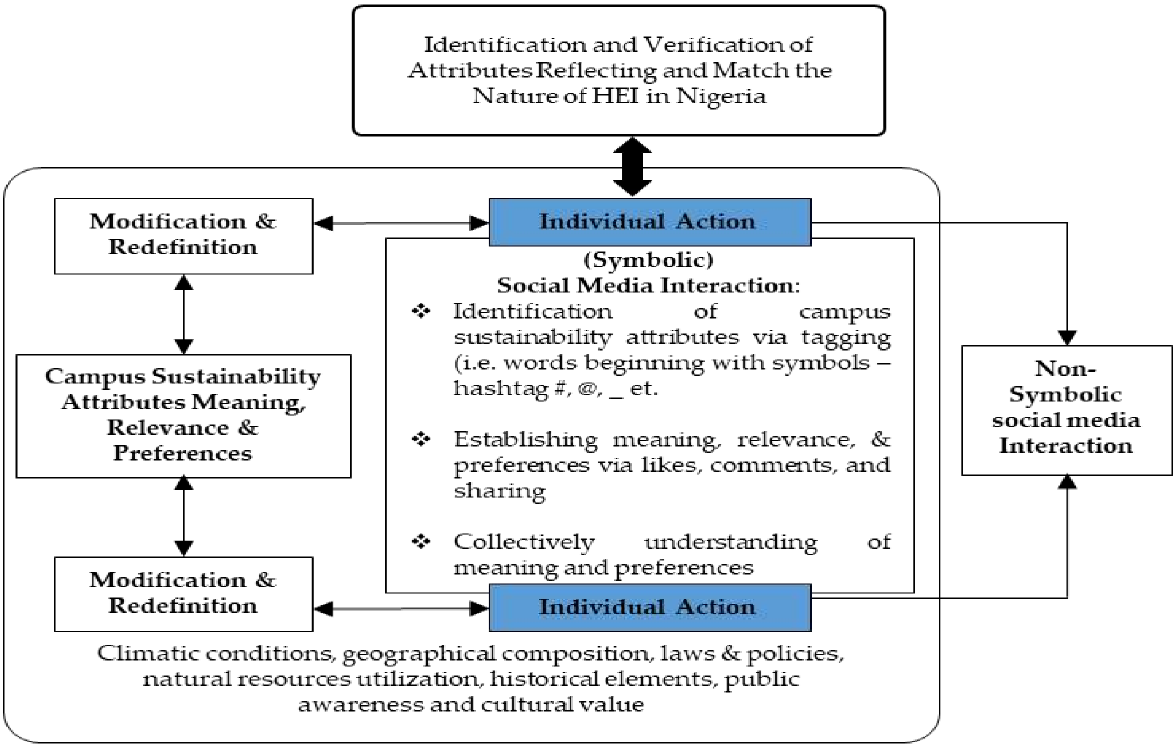
The review of the existing tools and the roadmap to constructing an appraisal model presented in section 3 led to the development of a campus-wide model for appraising the sustainability performance of spatial-based attributes in HEIs campuses in Nigeria.

6.5.1 The Model Theoretical Basis

Due to the non-utilization of a theoretical basis that ensures monitoring and appraisal of CSA using social media UGC, the authors adopted symbolic interactionism as a theoretical basis for appraising sustainability in HEIs campuses based on social media data. The theory has several applications in studies relating to CSA and framework development. Although many scholars have challenged the approach of symbolic interactionism, claiming that it only focuses on broad and macro-sociological issues (Reynolds, 1993), this criticism has been rejected (Maines, 1988; Tucker et al., 1988). Applying the theory in several other academic disciplines (Altheide, 2009) and other theories (Couch, 1984; Young, 1991) has further provided justifications to debunk the claims that the theory could not be applied at the micro-level and in other disciplines. Other scholars were also able to incorporate the epistemological assumptions of symbolic interactionism with other theories and other socio-cultural studies (Ashley, 1985; Batiuk et al., 1981; Corsaro et al., 1988; Winter & Goldfield, 1991).

Another scholar claimed that the theory utilizes secondary and survey data to conduct statistical analysis as well as to conduct applied socio-cultural research that is policy-related (Fine, 1993). This application shows that symbolic interactionism theory has a lot of applicability in CSA research and technology-driven resources, tools as well as artificial intelligence approaches like machine learning, deep learning, and sentiment analysis. I am not in any way intend to claim the supremacy of symbolic interactionism over other philosophical approaches despite its adoption in this CSA study. Adopting a social science theory such as symbolic interaction can serve as the beginning of innovative ways toward incorporating several related theoretical bases into the assessment of HEIs campuses in both the developed and the developing world involving huge social media information. **Figure 6.3** below presents the incorporation of the theory as a theoretical basis into the appraisal of sustainability performance in HEIs.

Figure 6. 3: Theoretical Basis of Symbolic Interactionism in CSA

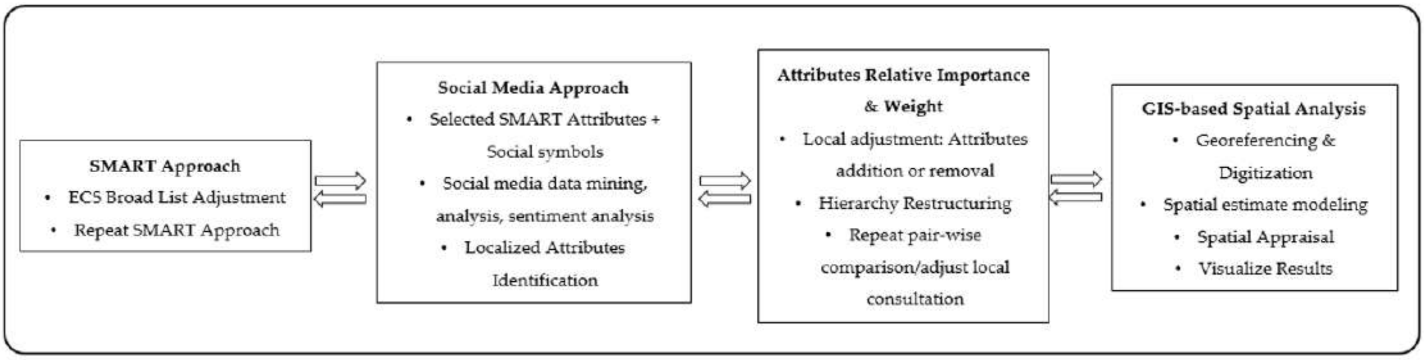


In this study, Twitter social media that display the concept of symbolic interactionism was utilized. On Twitter, users are identified based on the perception of others. Therefore, the HEIs communities' behaviors and discussion on Twitter social media were studied by identifying symbols (language) mainly used during interactions. Twitter and several other social media channels use the tag symbols to allow users to actively participate in comments and posts such as green campus, sustainable campus, green university, university sustainability, etc. For instance, tagging informs the users at the receiving end of posts, comments, and pictures that s/he have associated themselves with. Examples of tags are but are not limited to hashtag (#), @, //, _. Social media users use all these tags to interact with themselves on various platforms. With the identification of several symbols of communication and interactions on Twitter, the authors utilized the @ symbols of all official Twitter handles of universities in Nigeria to mine a vast volume of data and filtered to identify the campus sustainability indicators that mainly were discussed online.

6.5.2 Different HEIs Context Adaptability, Continuous Improvement, Monitoring and Review

The model is developed to allow for modification (as depicted in **Figure 6.4**) of campus-wide sustainability appraisal of different campuses within the Nigerian context and by extension to other sub-Saharan African nations.

Figure 6. 4: Modifiable Campus-wide Appraisal Model for HEIs



AHP allows for continuous improvement, advancement, monitoring, and review by repeating the pair-wise comparison process with local experts. This monitoring and review process is an improvement over most of the existing tools that do not justify the selection and weighing process for appropriating relative weights. The SMART Approach can be easily repeated after an adjustment to the ECS broad list. The third major assumption of symbolic interactionism states that "meanings are assigned and modified through an interpretive process that is ever-changing, subject to redefinition, relocation, and realignments" (Shalin, 1984) p.544. Because assigned meanings to the sustainability indicators in HEIs on social media continue to change and be modified, it perfectly justifies continuous monitoring and review of the CSA process. Unlike other appraisal techniques that fail to understand the need to modify their frameworks or continue to regularly conduct an appraisal, the concept of symbolic interactionism gives a philosophical justification for engaging in such activities. This also provides evidence for why several frameworks that did not incorporate theories experience model errors, wrong methods, inadequate selection of appropriate concepts, and a lack of persistence. The adoption of symbolic interactionism in campus sustainability will expand the comprehension of individual behaviors to the practice of sustainability in HEIs, primarily via social media interactions. Human beings establish new meaning and advance ways of responding to stimuli interpretation which makes them design a better future due to the process of interpreting meaning.

6.5.3 AHP Results and Indicators' Campus-wide Measurement

Completing the relative importance and weights of the indicators and their corresponding categories process (discussed in **section 6.4**) finalized the development of an appraisal model for the Nigerian context. The final categories and indicators weight derived from the local consultation based on pair-wise comparison AHP survey is present in **Table 6.2**. The results show that the transportation category and campus fleet indicators are the most important. Recall that the selected indicators for the model possess the SMART attributes; therefore, they are all measurable to calculate the indicators. **Table 6.2** also contains the campus-wide indicators measurement approach for actualizing the model within the Nigerian context. Campus-wide, spatial-based indicators vector, and raster data types obtained from HEIs, campus map, aerial/satellite images will be geo-referenced via spatial technique software to implement the appraisal process. Spatial technique software will also be utilized to display present sustainability status in addition to the future scenario simulation. Besides stakeholders ' participation via social media platforms, online spatial techniques application will further ensure public participation in the campus planning and appraisal process.

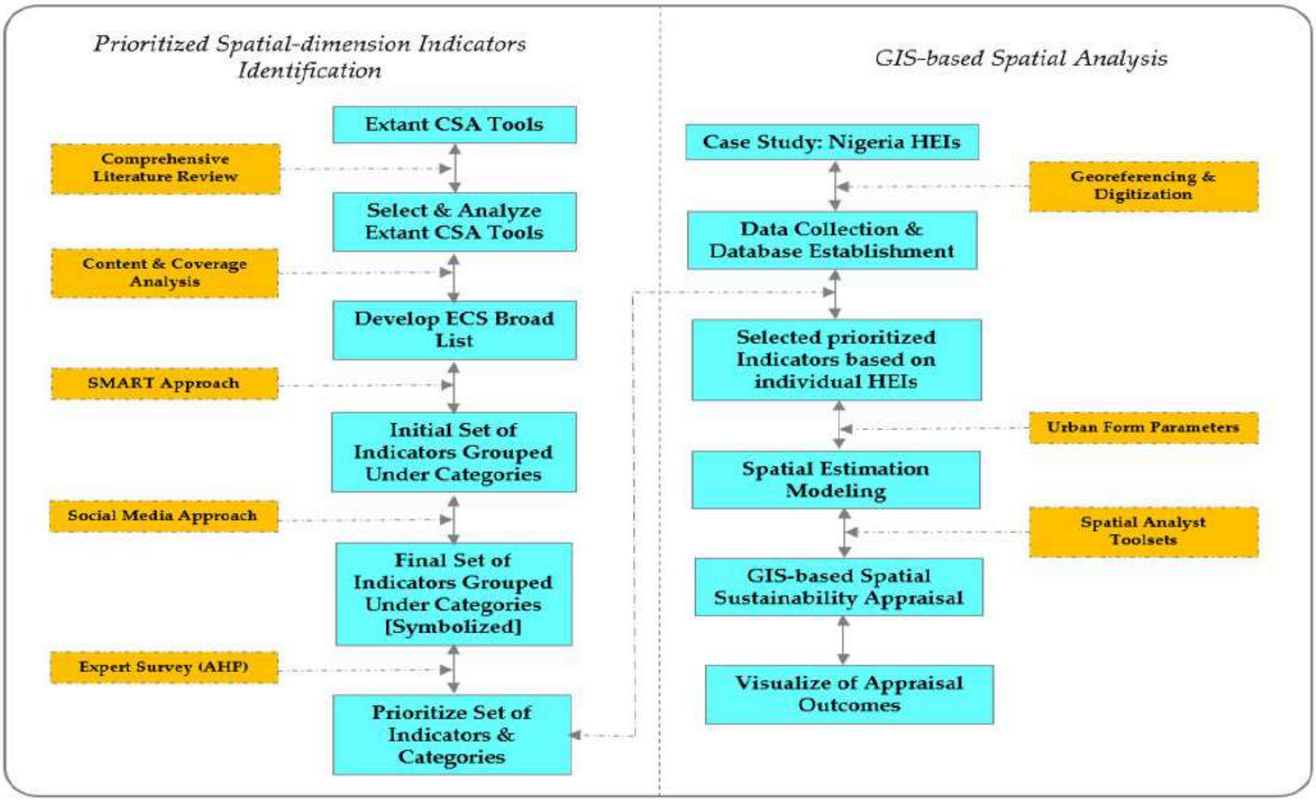
Categories	Weight	Indicators	Weight	Campus-wide Measurement
Environment	0.1309	Land	0.0328	- The acreage/area of green area, land, public space, and public space in m^2 - Area of heat islands in m^2
		Public Space	0.0437	
		Landscape	0.0211	
		Greenspace and Forest Land	0.0335	
Infrastructure	0.1234	Buildings	0.0911	- Area of buildings, green building with Certified LEED, natural heritage and physical structure in m^2 - Location of green buildings/buildings, natural heritage, and physical structure
		Green Buildings	0.0237	
Energy	0.1156	Greenhouse Gas Emissions	0.0174	- Location of renewable sources, greenhouse gas concentration, emissions, effluents, and waste concentration - Energy consumption in kWh - Quantity of electricity per area of solar - Area and percent of buildings that generate greenhouse gases - Greenhouse gases in CO_2 equivalent
		Energy Consumption	0.0891	
Waste	0.1630	Sewage Disposal	0.0398	- Amount of waste disposal and reduction in m^3 and metric tons - Location of sewage disposal - Area of waste collection in m^2
		Waste Reduction	0.1231	

Water	0.2005	Water Efficiency	0.0510	- Amount of water in m^3/litres/$ft.^3$/gallons - locations of water supply - Area of water supply
		Water Consumption	0.1490	
Transportation	0.2665	Campus Fleet	0.2016	- The dimension (1D, 2D, 3D) of cycling, pedestrian, ramp and campus route in m/km/km^2
		Pedestrians and Cycling	0.0654	

Table 6. 2: AHP Results and Indicators' Campus-wide Measurement

Finally, the MOCAM analytical framework is illustrated in **Figure 6.5**.

Figure 6. 5: MOCAM Analytical Framework



6.6 Conclusions and Future Research

Research is a systematic process, and sequential steps are required to achieve the goals and objectives outlined at the initiation of such endeavor. As such, a background study was carried out on (i) CSA tools, (ii) multi-criteria decision-making methods (MCDM), (iii) main societal-based social science theories, and (iv) social media platforms and scrapping tools. The systematic process involves a comprehensive review of more than 20 existing CSA tools, five main social theories, several social media platforms, data mining tools, and the major MCDM used in CSA. These processes and steps were carried out to achieve this study's aim, which is to develop a modifiable campus-wide appraisal model (MOCAM) for comprehensive spatial-based information and appraisal framework for policymakers. The identified research gaps in the literature were addressed, and the model was successfully created to address these challenges.

The background knowledge assists in establishing the current research gap that led to (a) adoption of symbolic interactionism as the proposed model's theoretical basis (b) selection of existing 13 CSA tools for comparison and eventual identification of spatial-based, campus-wide, and environmental-dimension categories and indicators (c) adoption of Twitter social media platform, Elastic Stack scrapping tool and eventual mining of UGC from the selected social media platform of HEIs for the identification of localized sustainability attributes based on the awareness and involvement of stakeholders (iv) adoption of AHP weighting method to determine the attributes' relative importance and weights. CSA with an approach involving Twitter social media data with a symbolic interactionist perspective is rare in literature, revealing the novelty of this research. The implications of this study for policymakers, managers of HEIs, and scholars in urban sustainability appraisal is the study's approach that can create a better method for conducting CSA, especially with the use of the open-source software (Elastic stack) that does not require any customization.

The roadmap to campus-wide sustainability appraisal (**Figure 6.1**) and modifiable model (**Figure 6.5**) guide in developing efficient, significant, innovative methods of conducting CSA in Nigeria HEIs. This article extensively discusses the three stages (i.e., SMART Approach, Social Media Approach, and Attributes Relative Importance and Weights). The next chapter on the fourth stage (i.e., Visualize Result) that will involve the selected campus sustainability indicators to conduct a campus-wide dimensional simulation modeling seems appropriate to visualize the impact of the indicators with a high and low level of importance. Future research should also ensure that the identified localized indicators via social media approach are thereafter subjected to machine learning and sentiment analysis using Azure machine learning to identify the users' negative, positive and neutral orientation and behaviors towards the level of sustainability across the HEIs campuses in Nigeria. Based on the tenets of symbolic interactionism, campus policymakers would be able to concentrate on how HEIs stakeholders and practitioners attached meaning to individual campus sustainability behaviors based on several factors. Finally, future studies should be conducted that will incorporate more extensive social media data from both official and unofficial Twitter accounts. Twitter accounts should be set up specifically to address the happening in Nigerian HEIs.

6.7 Chapter Summary

Institutions of higher education across the globe have commenced the appraisal of their sustainability performance via the utilization of various existing campus sustainability assessment tools. A comprehensive review of these existing tools reveals insufficient utilization of weighting methods and theoretical approaches that allow for monitoring, review, and enhancement of the appraisal process and tools. Social media and spatial-based indicators usage are also deficient in the existing tools. This chapter addressed these research gaps and developed a MOCAM for comprehensive spatial-based information and assessment framework for policymakers, local authorities, and campus planners in countries with unknown campus sustainability status. In this model, the SMART approach was utilized to identify environmental-dimension indicators with campus-wide and spatial-based attributes. Twitter social media platform, Elastic stack, and Python Library were used to extract and analyze local stakeholders' user-generated content to identify localized indicators. The AHP was used for the determination and analysis of the attribute level of importance and weights. The model also broadens the application of symbolic interactionism by translating it from the predominantly field of social science to sustainable campus appraisal.

CHAPTER 7: AN APPROACH TO APPRAISE CAMPUS-WIDE SPATIAL-DIMENSION INDICATORS IN NIGERIA HEIs[12]

7.1 Chapter Overview

In a research cycle, an essential phase is a validation (Hu et al., 2016). This validation is usually carried out at the final stage to evaluate the soundness, reliability, and authenticity of a study's proposed frameworks, approaches, methodologies, models, or systems (Ameyaw & P.C. Chan, 2016). Moreover, validations are carried out to appraise the extensiveness at which a proposed framework meets the requirements/demands of the end-users and stakeholders. Extant studies also reveal that validation is paramount in ensuring the appraisal of a proposed framework is conducted in a pragmatic, objective, reliable, appropriate, and suitable manner. This chapter utilized spatial strategy analysis via GIS software on a selected HEI campus in Nigeria to validate the study's proposed framework. Recall that in **Chapter 2**, CSA based on environmental-dimension indicators is akin to national spatial strategy. Rather than relying on experts' opinions for validation, this study's validation is a paradigm shift from the literature's extant studies.

7.2 Introduction

National spatial strategy (NSS) is one of several countries' concepts as a worthy endeavor for actualization. The concept was initiated to ensure a spatially balanced sustainable design, planning, and environmental infrastructural development. The concept aims at appropriating adequate considerations to its various dimensions in developmental projects. These various dimensions are fundamental to the existence of humans and a quality lifestyle. As such, a quality lifestyle could be efficiently realized via NSS. Different national, organizational, and institutional policies have also commenced incorporating NSS principles (Ministry of Municipal and Rural Affairs, 2016). However,

[12] This chapter is currently under review at the International Journal of Sustainability in Higher Education.

studies reveal gaps in implementing NSS principles due to the absence of a specific framework for linking its various dimensions (Ó'Riordáin & Van Egeraat, 2016).

Various world leaders adopted sustainable development goals (SDGs) in 2015 to implement the various goals of NSS. Being a global goal, goal 11 of the SDGs set out targets relating to sustainable spatial strategies for both developed and developing countries to draft national plans and strategies for achieving those targets on or before 2030 (United Nations General Assembly, 2015). HEIs' significance in ensuring awareness creation and implementing targets relating to sustainable spatial strategies have been recognized in their various programs through workshops, seminars, conferences, and declarations (Smaniotto et al., 2020). Besides, studies found that the actualization of sustainable spatial strategy plans and design will be more effective and worthwhile at the campuses of HEIs (Adenle et al., 2021). As such, multiple CSA frameworks and campus-based indicators have been established as guides, tools, and manuals for implementing SDGs and sustainable campuses' advancement.

Some of the attributes, indicators, and sub-indicators of sustainability at the HEIs are conceptualized with spatial strategy principles to ensure campus-wide environmental performance and sustainable development advancement (Adenle et al., 2020). When properly and efficiently incorporated into CSA projects or processes, indicators with spatial dimensions can perform the functions of fostering campus-wide environmental sustainability. The utilization of campus-wide sustainability indicators in advancing environmental sustainability at the HEIs has been confronted with challenges of (i) inadequate data and requisite information for CSA programs (ii) tools with the capacity of incorporating data needed for HEIs campus-wide CSA process (Alshuwaikhat et al., 2017a).

7.3 Literature Review

7.3.1 HEIs and Spatial Strategy

Investment in human capital is essential for every country in achieving sustainable spatial development, with education being a fundamental factor. Education enriches people's understanding of sustainable practices and behaviors. Specifically, it advances creativity and promotes innovative spatial technologies for sustainable smart campus development. Education also ensures environmental benefits to HEIs and individuals via knowledge dissemination that improves life quality, sustainable development, spatial growth, and wealth distribution that nations in both developed and developing aspire to achieve.

In recent years, there has been a mounting worldwide commitment on HEIs to address the issues related to the sustainable spatial development of the countries in which they are established (Bonander et al., 2016; Hayter, 2015; Trequattrini et al., 2018). Many papers available in corpus databases on HEIs locational spatial impacts show that many studies have been conducted in this area. Examples of studies conducted are university location spatial impacts on academic salaries or better salary schemes after graduation (Suhonen, 2013), student satisfaction (Wang & Chui, 2016), and expenses (Chankseliani, 2013). Others are impacts of university strategic spatial location on researchers' tendency to patent (Audretsch & Aldridge, 2009), teaching efficiency (Kantabutra & Tang, 2010), quality of education (Q. Chen & Wang, 2010; Le & Nghia, 2017), choices made by students (Alhelalat, 2015; Marconi, 2013; Mathooko & Ogutu, 2015), transfer of technology (Friedman & Silberman, 2003), a spin-off of research institutes (Jung & Kim, 2017) and obesity (Yang et al., 2017). A related study identified from the literature is on HEIs campus strategic location choices (Du, 2017). Many scholars have also identified HEIs as agents that ensure sustainable national development in different parts of the world (Boucher et al., 2003; Karatzoglou, 2013; Peer & Stoeglehner, 2013; Sedlacek, 2013).

In Qatar, a hub for knowledge to use HEIs in creating service activities and high value is contained in Qatar's development strategy. In Australia, one of the objectives of the Canberra Spatial Plan of 2004 was the move to ensure the spatially balanced distribution of educational facilities with significant HEIs as growth poles for sustainable development (Act Planning and Land Authority, 2004). Besides, educational institutions were named one of the significant strengths among multiple sector areas in Denmark's spatial development plans (Galland & Enemark, 2012). In 2013, a spatial development policy that centers on a detailed national plan was developed in Korea. The establishment of several HEIs hubs to ensure spatial development was formulated as a spatial development policy (Moon et al., 2013).

Furthermore, during the 1990s in China, the country's spatial strategy moves from development around the coastal regions towards regions within its interior parts along the development axes. The development of China's spatial strategy that ensures development along transportation corridors gave rise to a balanced spatial growth that provides equitable access to essential services. This spatial growth was achieved by establishing public services such as HEIs institutions and health facilities. More than 50 university towns had already been established in all China regions via China's National Spatial Strategy (Ding & Zhao, 2011).

During the 1980s in Saudi Arabia, despite the continuous improvement in the standards of services such as the provision of university education, the process also generated an imbalance in the relative levels of service provision. This spatial imbalance was attributed to internal migration due to insufficient established HEIs campuses in other regions. The few Saudi HEIs that provided favorable living conditions and economic opportunities such as job creation, social and human development could only do so in few regions. This growth pattern of the regional population indicated the evidence of sustainable spatial growth and development disparities. The inaugural NSS for Saudi Arabia was instituted in the 1970s by the Ministry of Municipal and Rural Affairs (MOMRA), with several modifications in the 1980s due to development changes across the Kingdom (United Nations Human Settlements Programme, 2016). In 2000, the Council of Ministers approved the country's current NSS jointly developed by MOMRA and the Saudi Ministry of Economy and Planning with support from the UN-Habitat (United Nations Human Settlements Programme, 2014). One of the NSS's primary objectives is to achieve regional and national growth spatially balanced between and within all regions across Saudi Arabia. The spatial strategy is based on corridors' development along with the major transportation networks. Each corridor comprises various sizes of population centers with the establishment of new HEIs campuses to serve as growth centers.

These findings are evidence to show that HEIs campuses are causative to national spatial strategies' goals. However, the NSS concept has always been placed on national, regional, and city growth based on HEIs campuses' utilization as growth poles. Considering the sustainable spatial growth and development of HEIs campuses, pragmatic studies emphasizing spatial-based and environmental-dimension indicators are lagging. As several scholarly articles have been published on the concept of NSS, HEIs campuses as growth poles for achieving NSS, HEIs strategic spatial locational impacts, the extent to which the extant HEIs have been appraised from the dimension of spatial strategy in achieving smart, sustainable campuses has not been adequately addressed. Besides, studies of this nature are absent within Nigeria's HEIs context.

7.3.2 Campus-wide HEIs Sustainability Appraisal: Spatial Strategy, Software, and Analysis

The operationalization of spatial strategy and analysis within the urban and city landscape scope has been reported in extant literature with various tracking, monitoring, and implementation approaches (Alshuwaikhat & Aina, 2006; Stylianidis, 2012). These studies' focus varies from urban sustainability attributes and indicators identification with technical definitions to measuring urban sustainability performance. Likewise, incorporating spatial dimension into this urban sustainability appraisal has been examined due to a more significant percentage of these developmental projects' spatial configuration. The environment's impacts could also influence the geographical complexity, land use, coverage area, and spatial integration level. On the other hand, the concept of sustainability does not have some predetermined outcomes, rather a process in space. Therefore, the geographic scale should be given preference when conducting sustainability that affects the human QOL (Bagchi-Sen et al., 2000).

Incorporating spatial strategy with the sustainability assessment or urban areas within the last decades has led to GIS and related spatial software to appraise environmental sustainability performance and environmental impacts of planning and developmental activities. A review of extant literature reveals the effectiveness of GIS, remote sensing, building information modeling, CityEngine, etc., in assessing regional and urban sustainability (Blaschke, 2001; Carsjens & Ligtenberg, 2007; Graymore et al., 2009; Luo et al., 2015). The spatial analytical tools in these spatial technologies and software have been utilized to perform various spatial analyses on locational data connected with their attributes. These spatial techniques can evaluate and measure urban spatial-based indicators data for urban sustainability assessment. Visualization of different urban landscape scenarios in addition to data manipulation and simulation of future scenarios can also be performed. These tools could be regarded as the essential software for the appraisal of urban environmental sustainability. Based on the reviewed empirical cases' findings, spatial strategies and analysis are paramount in implementing sustainability appraisal at the urban, regional, national, or transnational levels.

However, due to the large area of land occupied by most HEIs campuses across the globe similar in size and scale to some municipalities and neighborhoods, their environmental sustainable development monitoring also requires appraisal that is approached from a spatial perspective involving spatial linkage between environmental impacts and development processes. In identifying the integration of spatial techniques in campus-wide environmental sustainability appraisal, there is a need to review extant literature. Abubakar (2007) recommended using GIS to actualize environmental-dimensions management of HEIs campuses using a Saudi university as a case study. The recommendation for using GIS was due to the author's research outcomes of difficulties designing, planning, and implementing environmental management at the HEIs. The negative environmental impact of activities at the HEIs campus level is location-based with a spatial dimension. As such, the need for a tool like GIS with the capacity of monitoring spatial indicators in its database. The four roles of GIS in HEIs environmental management are (i) data categorization and management, (ii) campus-wide environmental dimension impact analysis, (iii) continuous monitoring and review, and (iv) auditing and checking.

To identify the use of GIS in extant CSA tools, Alshuwaikhat et al. (2017) examine two HEIs appraisal tools, which are the (i) GRI and (ii) STARS. Their review reveals the absence of spatial software in these tools. Adenle et al. (2020) extended the studies on spatial software utilization in spatial analysis of the limited spatial-dimensions environmental sustainability indicators in 13 extant tools with similar outcomes. After that, the authors proposed a framework for integrating environmental-related sustainability indicators based on spatial software for campus-wide appraisal without an empirical case study validation. Although, in advancing on the recommendation of GIS in HEIs campuses environmental dimensions' management, two empirical studies have been conducted within the context of HEIs in Saudi Arabia. A campus environmental sustainability appraisal of five categories within in King Fahd University of Petroleum and Minerals (KFUPM) (Alshuwaikhat et al., 2017a) and a CO_2 emission spatial estimation and visualization within the academic campus of King Abdullah University of Science and Technology (KAUST) (Adenle & Alshuwaikhat, 2017) was conducted via GIS software.

Despite the two empirical studies, Alshuwaikhat et al. (2017a) suggested future studies for their framework validation using a mock analysis and result comparisons. Environmental CSA's trend is towards utilizing various weighting methods that allow for an adjustable comprehensive campus-wide sustainability tracking and review of the various spatial-based indicators (Adenle et al., 2020b). Incorporating social media UGC of online HEIs stakeholders in selecting a specific geographical region or institution's spatial-related sustainability attributes is another paradigm shift (Adenle et al., 2020b). In ensuring the implementation of smart campuses and a CSA framework in Nigeria HEIs, an empirical study was conducted using Twitter social media UGC and AHP weighting technique to appraised the attributes level of importance (Adenle et al., 2021). Albeit, there is the need for the spatial strategy and analysis based on spatial technology software for campus-wide HEIs environmental sustainability appraisal in the country.

7.3.3 The Nigeria HEIs Context

Nigeria is a country located in the Western part of sub-Saharan Africa, and it is the most populous nation on the African continent. The country comprises 36 states and a federal capital territory, with each state containing no less than three HEIs. In Nigeria HEIs, campus designing, planning, implementation, and renewal are carried out based on a bureaucratic process. Also, incorporating SDGs targets associated with sustainable spatial strategies and planning is still at an infancy stage. In placing Nigeria on the path of environmental-dimension sustainability that entails installing solar power equipment and infrastructure to address the challenges of carbon footprint, the 2020 Nigeria Economic Sustainability Plan was initiated. A couple of governmental and non-governmental organizations and institutions have commenced incorporating environmental sustainability spatial planning principles and awareness creation.

HEIs are classified into three broad categories: (i) Universities, (ii) Polytechnic, (iii) Monotechnic, and Colleges of Education. Others are Colleges of Agriculture, Colleges of Health Technology, Technical Colleges, and School of Nursing and Midwifery. These institutions can either be public (owned by Federal or State Government) or privately owned by individuals, organizations, etc. The HEIs in Nigeria are coordinated, monitored, and supervised by the Federal Ministry of Education. While universities are accredited by the National Universities Commission (NUC), the polytechnics are accredited by the National Board for Technical Education (NBTE), and the colleges of education are accredited by the National Commission for Colleges of Education (NCCE). Campus planning involving the spatial allocation of land uses, infrastructure, and transportation routes is coordinated by the Federal Ministry of Works and Housing, the Federal Ministry of Education, and the designated department at the federal HEIs level. This spatial planning coordination process varies across the state and privately owned HEIs.

The country is currently experiencing the fastest increase in the establishment of HEIs campuses in sub-Sahara Africa. Nigeria is a suitable and perfect region for the development and implementation of sustainable spatial strategy campus initiatives, programs, and policies based on its procession of a large population, high rate of urbanization, and the highest number of HEIs in the whole of sub-Sahara Africa. As of 1970, there were less than 15,000 students in HEIs, which rise to approximately 1.2 million students in 2014 (Ademola et al., 2014). This rise in the number of students has also led to a dramatic increase in tertiary institutions. With the continuous increase in both population and land area for the establishment of HEIs campuses, there is a need to address several environmental challenges that are mostly due to unsustainable campus spatial strategies and analysis outcomes.

The country hosted one of the declarations on sustainability that focuses on higher education in 2009 (AAU, 2009). The declaration participants acknowledge that enough attention to conducting, disseminating, or implementing sustainability research and practice is lagging in Africa HEIs. HEIs in the African continent were encouraged to reassess their education system regarding sustainable development and campus sustainability appraisal. It was discovered that the websites of two Nigeria universities that signed the Talloires Declaration does not contain any information relating to sustainability accounting (Khan, 2013).

There are challenges of non-availability of digital base maps for spatial technology software designed to create facilities mapping (Makinde et al., 2017). However, various survey and topographical maps were created by different government and private institutions that could not be accessible to the general public for sustainable appraisal-related studies. Moreover, these maps are in various scales with different degrees of accuracy (Makinde et al., 2017). With the current rise in demand for efficient and user-friendly approaches for obtaining up-to-date spatial data and regular updates, there is a need to extract recent spatial data for campus-wide environmental sustainability appraisal based on spatial strategy and analysis. Ensuring that HEIs in Nigeria are planned to be developed into top-class international sustainable and eco-friendly campuses in the nearest future, a study of this nature is paramount.

7.4 Methods

A large percentage of the extant researches on the assessment of sustainability performance and practices in HEIs campuses are mostly based on (i) campus operations, (ii) financial management, (iii) community engagement, (iv) research, teaching, curriculum, and scholarship (Abubakar et al., 2016; Alshuwaikhat et al., 2016). A comprehensive review of extant CSA tools also revealed the dominants criterial for HEIs campus sustainability as (a) academia, (b) engagement, (c) environment, (d) innovation, and (e) management (Alghamdi et al., 2017) with the absence of spatially related software (Adenle et al., 2020a). Unlike the extant CSA tools and studies, this paper utilized a methodology that entails the following:

Webpage Content Analysis: This involves analyzing the study area website's content based on sustainability within its institutional framework (i.e., the university's commitment toward campus-wide spatial strategy sustainability) and selected campus-wide spatial-dimension sustainability indicators. Content analysis (Berke & Conroy, 2000) was used for the appraisal to guarantee objective, efficient, and complete appraisal of campus-wide sustainability-related policies.

Social Media UGC Content Analysis: This involves the content analysis of the study area official Twitter handle UGC based on selected indicators. There are approximately 3 billion users on various social media platforms such as Facebook, WeChat, Youtube, Instagram, Twitter, and WhatsApp (Clement, 2020). As such, extracting and examining the UGC from these online discussion forums offers different HEIs insight on sustainable development. Different HEIs stakeholders (i.e., students, teaching and non-teaching staff, sponsors, parents, etc.) are now actively communicating their experiences, sentiment, opinions, sustainability research outcomes on social media rather than the old media (initial communication channels). This active engagement of stakeholders is why the research trend is now directed to analyzing these platforms' UGC. This content analysis ensures an enhanced comprehension of essential components such as challenges identification and campus spatial strategy sustainability indicators.

Spatial Strategy Sustainability Analysis: This involves appraising the campus-wide environmental sustainability of spatial-based indicators based on spatial strategy and analysis. It incorporates various spatial techniques and appraisal methods for regional, city, and municipal sustainability appraisal from literature into CSA. In this study, the campus-wide sustainability spatial strategy and analysis data are retrieved from various sources such as (a) Spatial data that include vector data, raster data, and aerial/satellite imagery, (b) Attributes data (c) Metadata. The undertaking performed in this study involves evaluating the campus-wide sustainability of a university in Nigeria via the utilization of GIS and a set of spatial-based campus sustainability attributes and indicators.

7.4.1 Study Area

The University of Lagos (Unilag) is one of the earliest tertiary institutions widely recognized as "the University of First Choice and the Nation's Pride" in Nigeria. The main campus (i.e., Akoka campus), which in this research case study area, occupied a significant landmark in Lagos mainland metropolitan area. It is located on longitude 54^{0} 20′ E and 54^{0} 50′ E and between latitude 71^{0} 85′ N 72^{0} 10′ N (**Figure 7.1**). The main campus has experienced vast spatial growth and development since its establishment in 1962. The population of students and staff increased from a few hundred to around 100,000. The rise in population was due to several reasons. One such is an increase in educational qualification demands leading to a corresponding spatial development growth and expansion in campus-wide physical infrastructure and facilities.

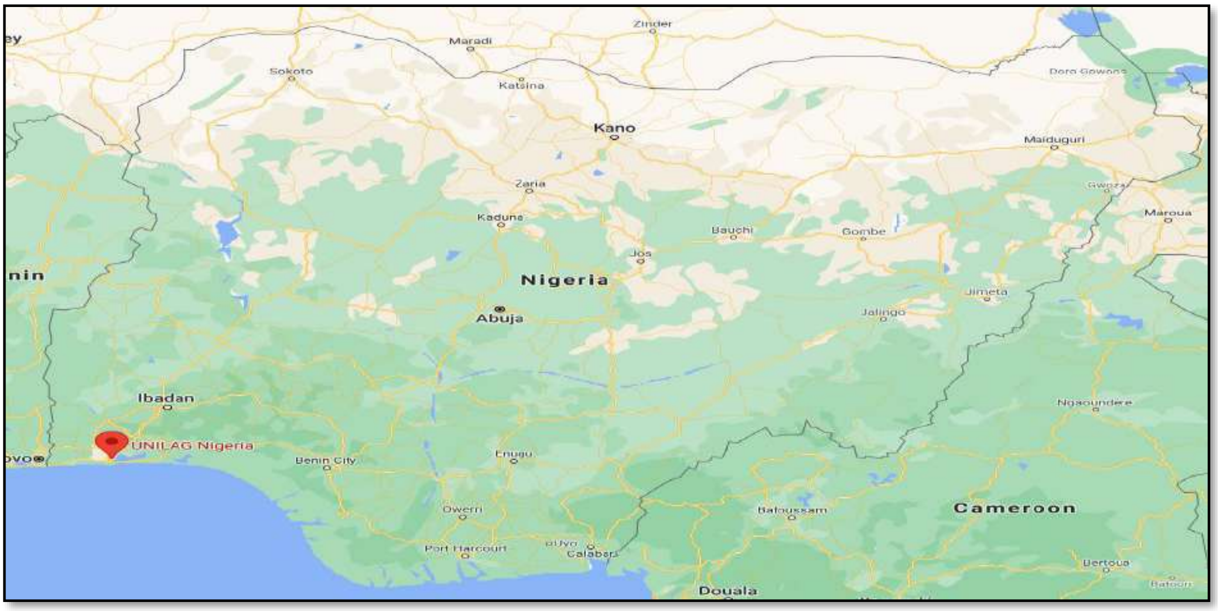


Figure 7. 1: Map showing the location of Unilag, Nigeria

This research designated the geographical area bounded by the mixed land-use communities of Akoka, Bariga, and Iwaya, a canal, and the Lagos lagoon as the study area for GIS-based spatial strategy and analysis (**Figure 7.2**). The designated land area covers about 325 Hectares (3.25 square kilometers).

Figure 7. 2: Georeferenced Map of Unilag. Google Earth, earth.google.com/web/.

7.4.2 Sustainability Appraisal of Unilag Website

The website of Unilag was surveyed and appraised on the incorporation of (i) institutional framework for sustainable development and (ii) campus-wide spatial-dimension sustainability indicators. The institutional framework is an essential component and an attribute of HEIs' commitment towards sustainability attainment (Abubakar et al., 2020; Lozano et al., 2015), such as campus-wide spatial strategy. This institutional framework is also contained in the global goal for 2030 (Abubakar et al., 2020). In this study, the extent to which Unilag institutional framework for sustainable development in terms of spatial strategies was appraised. The website appraisal was carried out from September 2020 to April 2021. Descriptive and content analysis was carried out on the extracted data.

After that, a list of campus-wide spatial dimension sustainability indicators was utilized to appraise the university's website. The indicators that are in line with the nature and demand of HEIs in Nigeria are adopted from extant literature (Adenle et al., 2020b; Adenle et al., 2021). The website's content is extensively examined, and the appraisal of the website-based content analysis was from the adopted campus-wide and environmental sustainability attributes and indicators with spatial dimensions. The ranking utilized in grading the extent of the selected spatial-dimension indicators incorporated in the institution's webpage is carried out quantitatively. The ranks, which are (i) no coverage, (ii) minimal coverage, and (iii) policy level coverage, were adopted from extant literature (Alshuwaikhat & Aina, 2006). The "no coverage" rank is applied to indicators that are not explicitly addressed on the webpage, while the "minimal coverage" applies to covered indicators without policy statements. However, the "policy level coverage" ranking is utilized when the spatial-dimension indicators are comprehensively covered in addition to clear policy statements.

In Nigeria, there is an absence of studies investigating the actualization of sustainable development relating to spatial strategy despite the awareness in the recent SDGs and existing literature. This study seeks to fill this research gap by evaluating the study area's institutional framework. The findings from the case study webpage content analysis are illustrated in the discussion section, and the direction of the campus-wide spatial strategy and analysis concerning CSA was identified.

7.4.3 Sustainability Appraisal of Unilag official Twitter Account

Figure 7.3 illustrates the authors' utilized modifiable approach to conducting the study area social media UGC content analysis. To achieve this task,

{1} the authors designated a workstation with a high-performance computer system (installed with Python 3 software and connected to a local server). **{2a}** Python Library: GetOldTweets3 0.0.11 was utilized in ethically extracting the UGC. Its utilization was due to restrictions by Twitter from mining all the available metadata directly from Twitter Application Programming Interface (API). **{2b}** The UGC with metadata were extracted using the Twitter username of Unilag based on modifications to the command lines available at https://libraries.io/pypi/GetOldTweets3. In this study, the utilized command-line for mining Twitter UGC from the official Twitter account of Unilag with output in .csv file format is provided below.

```
tweetCriteria = got.manager.TweetCriteria().setUsername("UnilagNigeria")\
                                            .setSince("2017-01-01")\
                                            .setUntil("2019-12-31")\
tweet = got.manager.TweetManager.getTweets(tweetCriteria)[0]
print(tweet.text)
```

Due to huge hardware resources requirements and limited support on configuration and usage, the authors subscribe to a free and open server cloud facility known as Logstash (https://www.elastic.co/logstash) for the storage of the extracted UGC and thereafter send it out for further critical analysis. However, the cloud data structure best supports "nljson" instead of "JSON"; therefore, an additional python library was used to convert from CSV to nljson. The conversion was carried out based on another modification to the command line interface available at https://pypi.org/project/NewlineJSON/.

{3a} Five campus sustainability indicators were selected in appraising the university Twitter UGC. These are (i) energy and climate (ii) infrastructure (iii) sustainable/sustainability (iv) waste, and (v) water. **{3b - c}** To ensure campus sustainability insights from the content analysis, the extracted UGC was transferred into Elasticsearch (https://www.elastic.co/elasticsearch). This transfer guarantees the cleaning and filtering of irrelevant content from the extracted UGC. **{4}** The content of the filtered UGC in Elasticsearch was thereafter transferred for content analysis and visualization using Kibana (https://www.elastic.co/kibana) based on the five selected indicators.

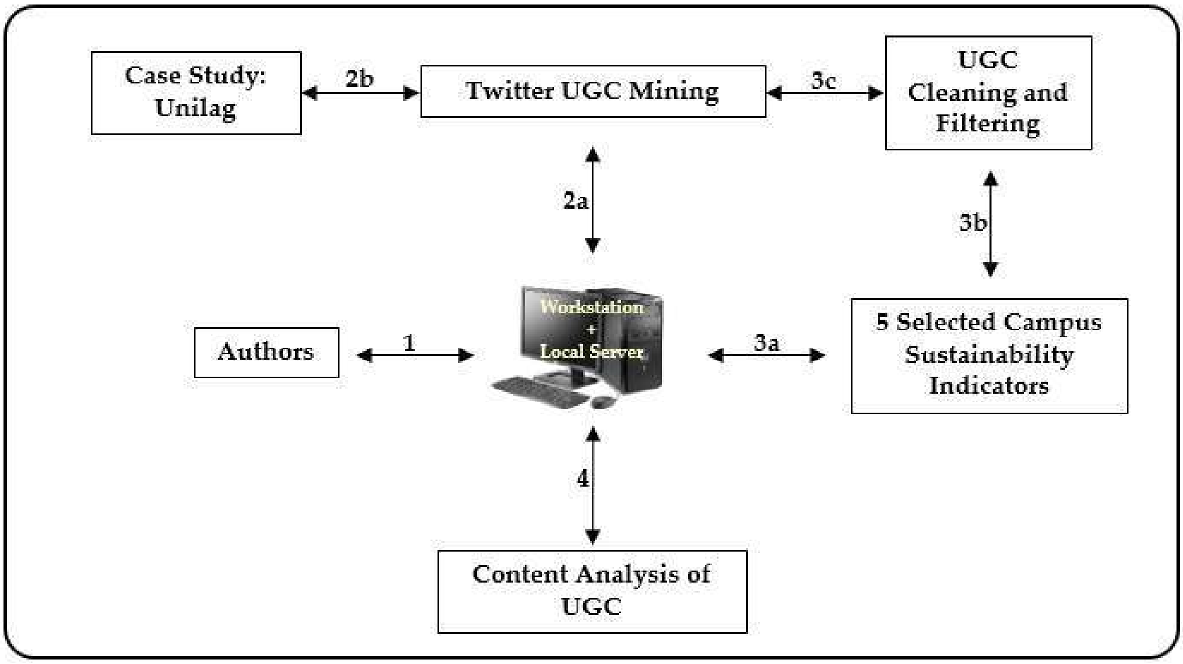


Figure 7. 3: The Study's Modifiable Framework to conducting UGC Analysis

This content analysis of social media in understanding HEIs sustainability engagement is a novel approach in CSA and social media big data as the authors utilized the usefulness of Twitter social media data in HEIs sustainable development. Furthermore, with the utilization of open-source software known as Elasticsearch, Logstash, and Kibana (ELK) Stack, now referred to as "ElasticStack" to provide a high-performance data collection, cleaning/filtering, and analysis without any need for customization, this approach could provide an excellent pathway for future research on campus-wide sustainability spatial strategy and analysis assessment.

7.4.4 GIS-based Campus-wide Sustainable Spatial Strategy and Analysis Appraisal

As depicted in **Figure 7.4**, this stage comprises two distinctive phases. Firstly, using a MOCAM analytical procedure, a set of prioritized campus-wide sustainability attributes and their indicators were identified to be utilized as input for the GIS-based sustainability spatial strategy and analysis. Subsequently, the appraisal was conducted to evaluate and visualize the outcome of the campus-wide sustainability performance.

7.4.4.1 Prioritized Indicators Identification for GIS-based Spatial Strategy and Analysis

The prioritized spatial dimension indicators and the modifiable analytical procedure utilized in this appraisal phase are adapted from the extant literature (Adenle et al., 2020b, 2020a; Adenle et al., 2021). This adoption eliminates the challenges of indicators' data availability and applicability in the case study campus. As illustrated in **Figure 7.4**, the modifiable framework is designed to allow for continuous improvement and review via repeating the SMART Approach, social media Approach, or the AHP pair-wise comparison expert survey. The modification can also be via a feedback process to ensure the most important or highly prioritized spatial indicators with the highest weights are appraised. The identified localized category for spatial estimation and indicators data collection are based on the AHP comparison matrix results of the indicators' relative importance and weights.

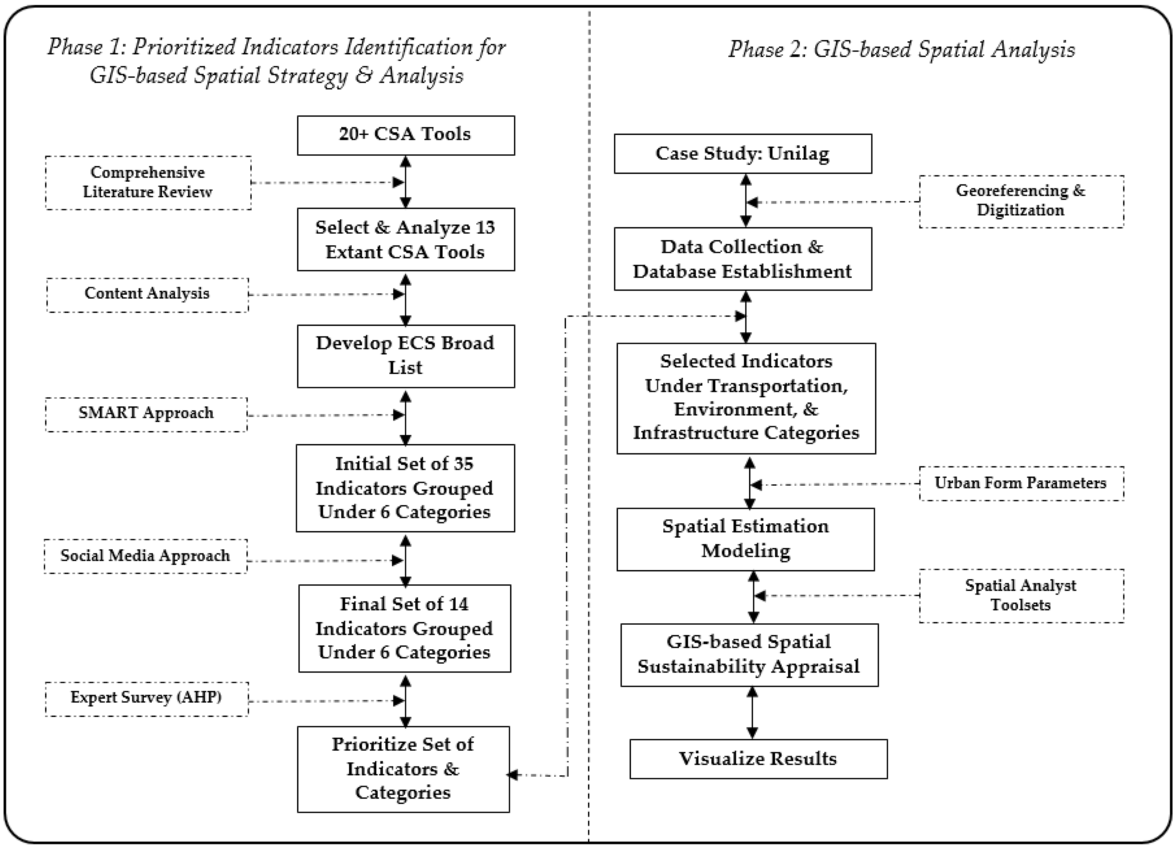


Figure 7. 4: Modifiable Analytical Framework for Appraising Campus-wide Environmental Sustainability

7.4.4.2 GIS-based Sustainability Appraisal

This campus data collection involves georeferencing and digitization methods using Google Earth Pro and ArcGIS 10.5.1. In georeferencing the study area, the location of Unilag was appropriately zoomed to capture its boundary on Google Earth Pro, and four ground control points (GCPs) were added. While the overall map area was saved in a jpeg image, the four GCPs were converted to shapefile in ArcMap using the conversion tools in ArcTool box from (keyhole mark-up language) kml to layer in WGS_1984 spatial reference. After that, the map area in jpeg was georeferenced by fitting the four GCPs and then rectified (see **Figure 7.2**). The final stage of the map production, data collection, and database establishment are via digitization - entailing the creation of multiple features from Google Earth Pro into the study's geodatabase in ArcCatalog. The established database consists of information relating to the spatial-based indicators of the campus, i.e., campus-wide measurement of cycling, campus/pedestrian routes, acreage of green areas/buildings, and location/names of public spaces, water supplies, etc.

In this study, the GIS-based spatial analysis is restricted to three categories. First is the transportation category, with the highest importance for campus sustainability performance appraisal in Nigerian HEIs (Adenle et al., 2021). The second category is the environment, focusing on the public spaces within the study area for spatial strategy analysis. The last category is infrastructure. To achieve spatial strategy analysis and sustainability evaluation, spatial estimation based on recognized standards was adopted from the extant literature. During the spatial estimation modeling stage, the study utilized 400meters as an optimum pedestrian and cycling distance with the assumption that public spaces, facilities, and infrastructure should be located within 400m of campus population to be accessible. The 400 meters buffer size is adopted from the extant literature (Bojorquez et al., 2018; Rijsman et al., 2019). ArcGIS Online is utilized in entering the 400 meters around seven selected public spaces in Unilag to access the buildings (i.e., dormitories and academic premises) within the conventional buffers. In estimating the areas within the campus that the Fire Department could reach, a driving time of 5 minutes (Huang et al., 2019) was utilized in the study for the drive-time areas spatial strategy analysis.

After the spatial estimation modeling, Spatial Analyst Toolsets (i.e., (i) Buffers and (ii) A drive-time area) were utilized for the GIS-based spatial sustainability appraisal of the study area. The outcomes, therefore, show the categories of the campus-wide sustainability of the institution demanding advancement, as illustrated in the Discussion Section. Unlike the extant CSA tools, the results could be visualized, saved, printed, shared, and easily interpreted by most HEIs stakeholders.

7.5 Results and Discussions

7.5.1 The Commitment of Unilag Towards Campus-wide Spatial Strategy Sustainability

This section is in two parts. The first part discusses the scale at which the case study HEI incorporates institutional framework to governess, safeguard and promote its campus-wide sustainability initiatives: (i) visions and mission statements, policies, and strategy for sustainable campus (ii) campus-wide sustainability development governance (iii) guidelines, appraisal and reporting of campus-wide sustainability development (iv) partnership and networking toward campus-wide sustainability, and (v) sustainability ranking and rating. The second part illustrates the content analysis of the study area website.

7.5.1.1 Visions and mission statements, policies and strategy for sustainable campus

The development of a campus-wide spatial sustainability vision and mission that illustrate the policies and strategies that a campus aspire to actualize in time to come is a significant parameter of HEI's dedication to sustainability. In Unilag, campus-wide sustainability strategy and policies are not explicitly mentioned in the institutions' vision or mission as well as the units responsible for sustainable development. However, they were referred to in the current university's vice chancellor's strategy for the campus infrastructure. These specific statements could assist in conveying the spatial-dimension campus-wide sustainability objectives and directions of the institution. Regarding the availability of precise/identifiable campus-wide sustainable development plans and spatial strategies as accessible in numerous HEIs in the developed nations, this study could not obtain a clear campus sustainability plan on the institutions' website. The documents of the university's campus master plans or spatial strategy plans could not be obtained on the webpage for the content analysis of their sustainability coverage.

7.5.1.2 Campus-wide sustainability development governance

Accomplishing campus-wide spatial strategy sustainability at HEIs level could be actualized via establishing independent and committed centers, units, departments, or offices with human resources, finances, and assignments for sustainability governance. In Unilag, the institution has established a dedicated center known as the "Centre for Housing and Sustainable Development" for campus-wide and related sustainable development governance. This center is in addition to the "Works and Physical Planning" unit that governs the spatial planning and development of the main campus. The campus-wide sustainability campus governance in the university could be regarded as the responsibilities of these two units. Although the Works and Physical Planning unit webpage on the university website contains no information and the Centre for Housing and Sustainable Development vision/mission statements do not explicitly refer to sustainability development.

7.5.1.3 Partnership and Networking Toward Campus-wide Sustainability

Attaining campus-wide spatial strategy sustainability within tertiary institutions also incorporates a diverse partnership with relevant stakeholders within and outside the campus community, governmental and non-governmental institutions for pragmatic betterment. The prominence, influence, and dedication toward campus-wide sustainability advancement from HEIs rises when championing the initiative toward establishing sustainable communities. Networking ensures the sharing and transfer of best practices of campus sustainability initiatives. The webpage content analysis reveals that the university has a partnership with different agencies, ministries, and departments at the national, state, and municipal level. Collaborations with private institutions and community outreach programs relating to campus sustainability were observed. Networking with different international agencies and institutions was also revealed from the content analysis.

7.5.1.4 Sustainability ranking and rating

Many HEIs dedicated to actualizing campus-wide environmental sustainability do engage in campus sustainability ranking and rating. Others involve themselves in global sustainable campus associations or accreditation/certification organizations. These ranking and rating tools appraise the HEI's to ascertain the level at which sustainable practices and performances have been achieved. In this study, the international-based HEIs campus sustainability appraisal tools based on Adenle et al. (2020a) research was utilized in assessing the involvement of Unilag. These tools ensure HEI's sustainability performance rating and are internationally certified as excellent evaluators of an institution's commitment to sustainable development.

Another essential dedication to campus-wide sustainability is the signing of HEIs-specific international declaration on sustainability. For instance, there are currently over 400 university members as signatories to the 2005 Talloires Declaration, with several African HEIs as members. However, the outcome of this study shows no indication of Unilag signing any campus sustainability-related declaration nor ranked/rated by the selected appraisal systems.

7.5.1.5 Guidelines, appraisal, and reporting of campus-wide sustainability development

Campus-wide sustainability appraisal and reporting are an essential aspect of environmental sustainability development at tertiary institutions and paramount measures of a suitable institutional framework. They entail procedures, methods, and benchmarking of specific campus-wide sustainability attributes and indicators. These are conducted regularly, and their outcomes are reported to ensure that more efforts towards campus-wide sustainability performance are actualized. Similar to the case study's content analysis based on sustainability ranking and rating systems, no information concerning the appraisal of the Unilag sustainability standing and reported aftermath that could ensure identification of areas needing improvement and the proposal of ameliorative plans. As such, the need for extra exploration in the case study university, unlike those discussed earlier.

7.5.1.6 Content Analysis of campus-wide spatial-dimension sustainability indicators

The findings of the content analysis of the Unilag based on the campus-wide spatial-dimension sustainability indicators reveal that the website does not sufficiently deal with the analyzed subject. As contained in **Table 7.1**, the outcomes reveal four of the 14 indicators are covered at the policy level coverage showing the inadequacy in their coverage.

Table 7. 1: Indicator-based Content Analysis of Unilag webpage

Categories	**Indicators**	**Ranks**
Environment	Land	No coverage
	Landscape	No coverage
	Public space	No coverage
	Greenspace and forest land	Policy level coverage
Infrastructure	Buildings	No coverage
	Green buildings	No coverage
Energy	Greenhouse gas emissions	No coverage
	Energy consumption	Policy level coverage
Waste	Sewage disposal	No coverage
	Waste reduction	No coverage
Water	Water efficiency	Policy level coverage
	Water consumption	No coverage
Transportation	Campus fleet	No coverage
	Pedestrian and cycling	Policy level coverage

The policy statements of these four indicators do not encompass the total of the essential aspects of campus-wide environmental sustainability concerning the indicators. The university vice-chancellor's strategy on the four indicators ranks as policy level coverage only specify financing of sustainable power, water, good road network, and the green environment without elaboration and explicit statements on actual implementation. The Unilag website approaches the topic relating to campus-wide environmental sustainability attributes in an outdated way lacking the paradigm shift as well as the systematic approach indicated in extant literature. This result reveals a need for the institution to review its webpage content to ensure more campus-wide sustainability policies and statements based on a conventional systematic approach that will hugely advance the campus planning, designing, and operations in a sustainable manner.

7.5.2 Evaluation of Unilag official Twitter Account UGC

The official Twitter handle (@UnilagNigeria), with over 25 thousand followers, was created in January 2017 with regular updates with data sources relating to campus-wide environmental sustainability. Since its creation, the Twitter handle has generated several thousand UGC. However, the mining process involving the username of the official Twitter account of the case study with bound dates (1st January 2017 to 31st December 2019) led to 1989 UGC. The UGC with metadata between May to July 2017 were extracted from the official Twitter account of Unilag for the examination and the appraisal of sustainability content on its social media platform. This volume of extracted data was due to storage capacity limits and the challenges of retaining or extending the stored UGC in the utilized cloud storage facility.

From these UGC, only 27hits contain the study’s five selected campus sustainability indicators. The 27 hits were later reduced to 21 hits after further filtering was carried out that discovered UGC repetition and selected sustainability indicators as hashtags and not within the UGC content. Thus, there are 54, 52, and 5 retweets, favorites, and replies, respectively, from the filtered UGC. **Table 2** contains the UGC containing the study’s selected sustainability indicators.

Table 7. 2: Content Analysis of User Generated Content

Indicators	UGC	Replies	Retweets	Favorites
Energy and climate	#NextGen workshop has ended. It what a great workshop with fantastic energy from everyone involved @The_ACU @UnilagNigeria	1	1	4
	@tundefashola 's energy speech @UnilagNigeria gives light as to why Nigeria has epileptic electric power supply.	0	2	0
	Inspiring words from the UN Boss @EdwardKallon on #Youth4Peace ~ youths have the energy to make change possible.	0	8	13
	EarthDay 2017 @Unilag. Climate literacy and tree planting exercise. 27th April.	0	0	1
Infrastructure	Same challenges with Unity Schools. Totally exceeding their carrying capacity, infrastructure run down, and no consistency in aligning needs...	0	0	0
Sustainable/sustainability	Time to Return to Sustainable Architecture @UnilagNigeria	0	0	0
	Private Public Partnership as a #Vehicle for Sustainable #Pharmaceutical #Education	1	2	1
	how PPPs must be sustainable and \"bankable\" to attract private sector interest	1	0	1

	Nation\u00e2\u0080\u0099s Growth and Sustainable Development\". An eye-opening lecture it was...pic.twitter.com/vb4b0wHyqV	0	0	0
	Prof. Adebamowo explains the meaning of the term Sustainable Architecture #InauguralLecturepic.twitter.com/lYqKnOEMbx	1	12	15
	He explained that to understand the meaning of 'Sustainable Architecture', review the origin of sustainability movement	0	6	2
	While discussing the principles of Sustainable Architecture, the Prof. on a lighter note, encouraged couples to coexist	0	4	1
	Prof. Adebamowo wowed the audience with a 3D illustration of proposed architectural designs using Sustainable Architecture	0	4	3
	#Upcoming: French Embassy Organises 2nd Round-table on Sustainability in Architecture, June 1 The Embassy of...	0	1	1
Waste	We are aware that @UnilagNigeria recylces all plastic waste in the school. We are sure this is because its easier to collect plastic bottles	0	0	0

	We have waste sorting centres, from which recycling plants (private sector) pick up materials. cc @SurprisingLagos Turn waste to cash.	0	1	0
	#InTheNews UNILAG generates \u00e2\u0082\u00a65m from waste recycling https://goo.gl/tgJ7TQ	0	4	4
	ACU member @UnilagNigeria makes 5 million Naira through its #recycling initiative http://mashable.ng/unilag-generates-n5m-from-waste-recycling/ \u00e2\u0080\u00a6 #highered	1	2	1
	We still sort our Waste @UnilagNigeria ....Reducing our waste footprint... Committed to\u00e2\u0080\u00a6 https://www.instagram.com/p/BXZBRUwlHMS/	0	0	0
Water	They protested because their meal was tampered with. We protested against water and light and got rusticated	0	6	4
	University of first choice and the nations pride, the only cosmopolitan university in Nigeria, accessible by rail, road air and water	0	1	0

The result shows that sustainable/sustainability has the highest importance, with nine UGC containing the indicators with three replies, 29 retweets, and 24 favorites regarding the level of importance for the five selected sustainability indicators. The next important sustainability indicator within the university social media context is energy and climate, with four UGC followed by waste and water. The least important amongst the five selected sustainability indicators is infrastructure, with one UGC and a corresponding zero reply, retweet, and favorite. From amongst the UGC with the selected indicator with the most crucial level, the need for sustainable architecture was contained therein. The "Time to Return to Sustainable Architecture" is now with an appraisal process focusing on the campus's sustainable spatial planning and strategy implementation.

7.5.3 Campus-wide Environmental Sustainability Appraisal of Unilag

Figure 7.5 revealed the buffer analysis of access of the campus residents to the selected public space facilities (Multipurpose Hall, Central Mosque, Chapel of Christ, Sports Center, Guest House, Main Library, Medical Center). With the 400 meters buffer, the analysis shows a distributive inequality concerning access to the selected public facilities and medical facilities from the student dormitories and academic buildings. While the medical center is far from around 95% of the campus population, the Sports Center could only be easily accessible by those within dormitories and academic premises at the campus entrance. On the other hand, the campus relaxation center and the Main Library are mainly accessible to those at the North-East axis of the campus. Thus, implementing a sustainable spatial strategy will improve the campus community's access to equal public facilities and medical centers.

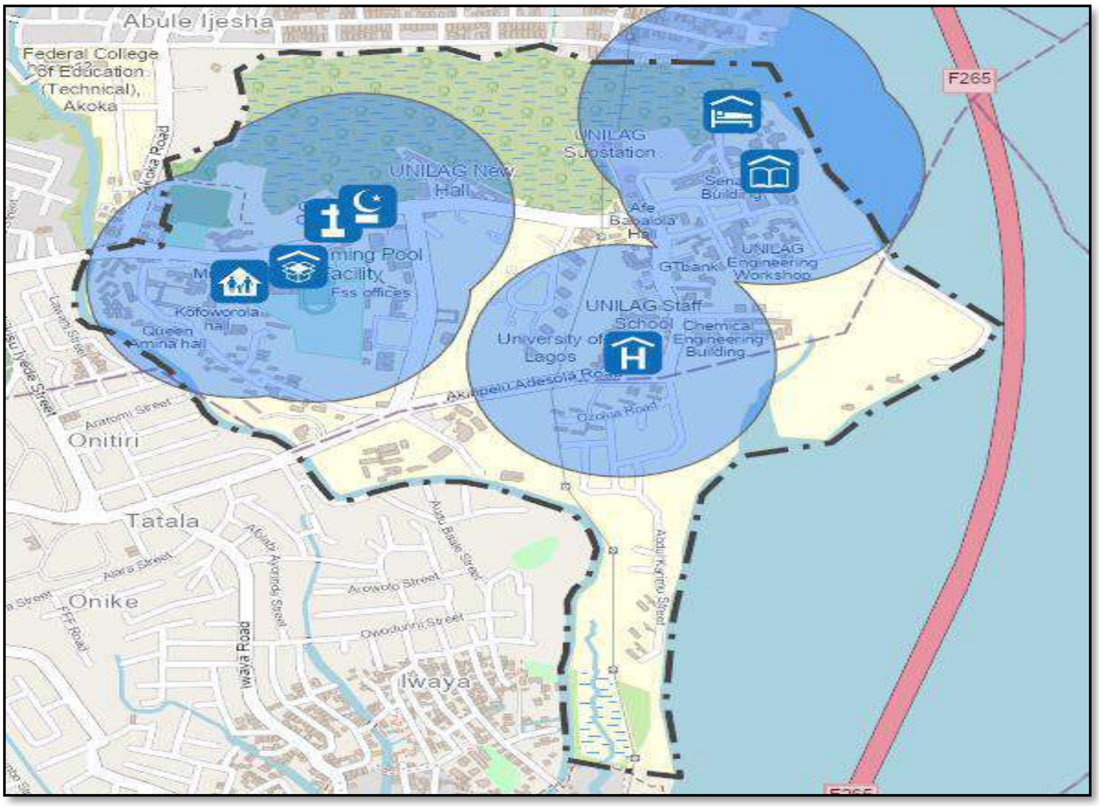


Figure 7. 5: Buffer of Unilag Public Spaces and Medical Center (400m)

However, the drive-time area analysis shows that all significant buildings, facilities, and infrastructure within the campus could be reached within 5 minutes of driving time (see **Figure 6**).

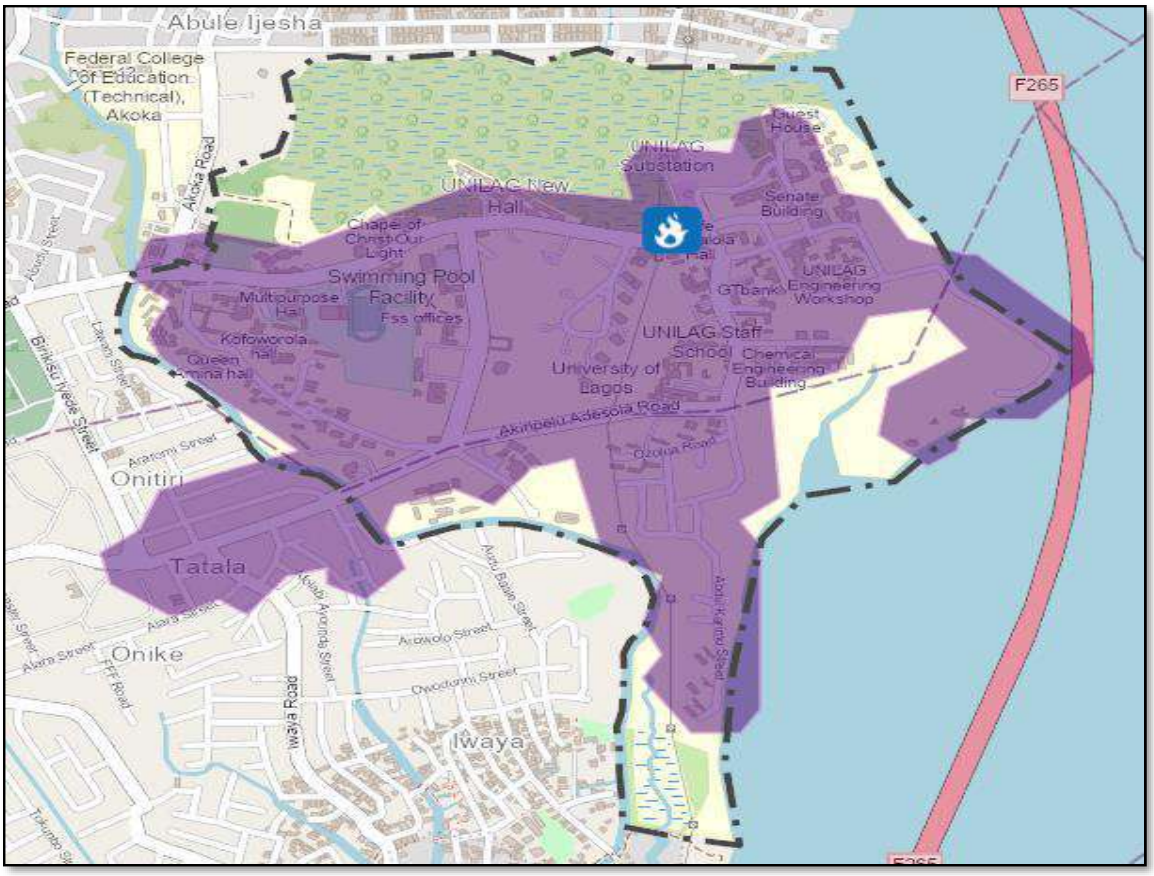


Figure 7. 6: Travel From Unilag Fire Station (5minutes)

7.6 Conclusions and Limitations

This study is an initial attempt to implement the analytical MOCAM for assessing sustainability performance and spatial strategy at the campus level. The model involves the innovative social media approach and the SMART approach, ensuring that only measurable and relevant spatial indicators are evaluated. The framework is utilized in Nigeria's university campus to appraise its campus-wide sustainability performance via a GIS-based approach. This GIS-based method appraised the study area's spatial strategy and campus-wide sustainability using spatial-dimension indicators underneath the transportation, environment, and infrastructure categories. In addition, the UGC of the official Twitter social media and the website content based on sustainability within the institutional framework were also examined. The outcomes of the study’s HEI webpage and Twitter social media UGC analysis reveal dimensions of campus-wide environmental sustainability not considered. Besides, the spatial strategy and campus-wide sustainability analysis via GIS software reveal unequal public facilities distribution patterns but well-planned fire stations against hazards. The practical policy implication of this study is that the propagation of sustainable campus growth and development in developing countries could become more effective with the adoption of this study's approach. The social implication is that a continuous increase in awareness of HEIs establishment, planning, and sustainability appraisal based on spatial strategies would influence more crucial stakeholders, i.e., students and staff, towards environmental sustainability and quality lifestyle progress.

Despite realizing the study's objective, some limitations exist. The outcomes of this study have revealed the relevance of environmental-dimension indicators with spatial attributes in campus-wide sustainability via GIS analytic toolkits. However, such spatial analysis demands regularly updated spatial data. As such, this nature of sustainability appraisal could be impeded by data inadequacies. In this study, a simplified buffering analysis was utilized to ensure optimum accessibility level. An advanced spatial analysis via buffering could be used in future studies for results comparisons. Further, while accessibility to selected facilities within the study area was considered in this research, future research could appraise the facilities' capacities regarding the total number of people within the campus. Future studies advancing this study could also utilize other spatial strategy modeling and analytic tools to appraise and model campus-wide sustainability changes in the study area. These toolkits could also be extended to other campuses of HEIs in Nigeria using other prioritized sets of indicators and categories. Due to the recent Covid-19 outbreak that restricts travel and access to relevant data challenges in a developing country like Nigeria, the case study data were georeferenced from satellite images. Although there might be discrepancies between the georeferenced maps, google street maps, and the actual dimension, the results present a valid situation useful for sustainability planning in the study area.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Chapter Overview

A synopsis of this research and the integrated methods for implementing the study's aim, goal, and objectives have been discussed in the preceding chapters. In this chapter, the research is brought to a logical conclusion. First, a second look at the research aim and objectives was provided, in addition to the summary of their actualization. This summary was followed by the study's research significance and contributions to knowledge gaps. Also presented are the summary of some of this study's limitations, recommendations, and directions for future research. These are in addition to those already discussed in the previous chapters of this thesis.

8.2 Research Aim and Objectives

The proposed research aims to develop a campus-wide, spatial-based, and environmental-dimension sustainability indicators framework for the appraisal and visualization of sustainability performance within the campuses of HEIs in Nigeria. The goal is to set up performance-based spatial indicators to appraise campus-wide sustainability for QOL and visualize the outcomes via spatial technology. Visualizing the appraisal outcomes via spatial technology requires selecting appropriate campus sustainability categories and indicators as well as a framework connecting them.

Specifically, the research objectives are as follows:

(i) To identify the campus-wide environmental sustainability categories that reflect and match the nature of Nigeria HEIs campuses. (ii) To identify spatial-based indicators appropriate to appraise the identified campus-wide environmental sustainability categories. (iii) To establish a practical measurement mechanism to appraise each sustainability category and spatial-based indicator. (iv) To determine and verify the relative importance of each category and indicator and assign them the appropriate weight. (v) To propose a framework that represents the linkage among the attributes (categories and indicators) in the form of a spatial data infrastructure model based on the Nigeria campus setting sustainability challenges. (vi) To test the proposed model within the context of spatial strategies to appraise a selected campus in Nigeria.

In achieving the above research objectives, multi-perspective/integrated approaches were utilized as summarized in Chapter 1 and described and implemented in Chapters 2 – 7. Besides, the central outcomes and research contributions to knowledge gaps, as described in the preceding chapters, are abridged in this section by examining each study's research objective.

8.2.1 To Achieve Research Objectives

Although, there are many well-known, established assessment tools with the tendency of witnessing more in the coming years. After conducting a comprehensive review of extant literature, several CSA tools were studied and examined. However, this study's selected tools were selected based on the following criteria: (1) they are all available in the English language and easily accessible on the internet. The tools identified but not written in English, such as one developed by the German Commission for UNESCO, were excluded from the list. (2) they are indicator-based appraisal frameworks. The selection of tools based on indicators was because they provide platforms for easy measurements and comparison. Appraisal tools based on narrative assessment and an account of sustainability status were excluded. (3) they are developed specifically to be utilized in HEIs. These tools are primarily addressing specific requirements within HEIs campuses. (4) they are not designed for individual tertiary institutions but rather for institutions at either global, continental, regional, and national level, and (5) their design approach, structure, background information, adopted criteria, and indicators are all available in the form of either a technical manual, reports, documents or articles. Those online-based or well-known tools (such as The Green Plan and Benchmarking Indicators Questions – Alternative University Appraisal) but without their reference sources were excluded.

The comprehensive list of sustainability indicators peculiar to HEIs across the world was carried out by identifying and extracting all the various categories, indicators, and sub-indicators in the 13 CSA tools. A total of 55 categories, 220 indicators, and 266 sub-indicators were successfully identified. After that, the indicators were subjected to exclusion criteria to ensure that the only relevant indicators to the scope and focus of this study were identified. The focus/scope of this study is on campus-wide (spatial) planning and measurable environmental pillar of sustainability that affect HEIs campuses in Nigeria. This focus is because HEIs campuses in Nigeria have substantial geographical areas (Adeniran, 2015; Adeniran, 2014) with severe impact, and specific campus spatial data could be extracted without reliance on official data. The study also focuses on environmental and spatial-based indicators due to an increase in spatial decision support systems research which has not been extensively covered in campus sustainability research. As such, all the indicators that focus on aspects such as sustainability curriculum in HEIs, socio-economic sustainability and accountability, and many more were excluded from the list.

The stage that follows merged all the repeated indicators and then structured the reduced lists into only two hierarchies. This reduction was made to eliminate users' challenges of the proposed appraisal model of not understanding or utilizing it due to complexities. For instance, Lozano (2006) observed that the GRI indicators are too large and made it difficult for benchmarking and longitudinal comparison. In the process of structuring the sustainability indicators to fit the scope of this study, minor changes were carried out although the categorization adopted in the 13 CSA tools was taken into considerations. The uniqueness of each sustainability indicator was investigated based on their operational definitions. These operational definitions were considered to eliminate the challenges of differences in defining and measuring the selected tools' indicators. Subsequently, the remaining indicators in line with the study's scope were used as keywords to filtered the Twitter social media data mined from Twitter handles of 142 Nigerian universities (34 Federal, 44 states, and 64 private).

In ensuring that scholars conducting studies on big data and machine learning-related topics, Twitter, Inc. made available data that the users have decided to release with people from around the globe for researchers after an application is granted. At the initial stage of this study, Logstash was utilized to extract tweets from Twitter via Twitter Application Programming Interface (API). After several attempts without essential data, a Python 3 library (GetOldTweets3 0.0.11) in addition to specific command lines and a specific timeline was used to mine around a million tweets in CSV format from 142 universities in Nigeria. After that, Python 3 library was utilized again with another set of command lines to ensure piping to another file in nlJSON format and run yet another command (Logstash: configuration file to cloud with key). This piping was because the CSV file format extracted data are not in the proper configuration for data analysis. Then, Logstash was used to feed the mined data into Elasticsearch for data cleaning, while Kibana was used for data analysis. As for identifying indicators for sustainability peculiar with Nigerian HEIs, the approach adopted at this stage of the study is the identification of Twitter UGC that contain the environmental-based sustainability indicators that are in line with the scope of this study. The final filtering/selection process in ensuring that only Twitter UGC containing the targeted spatial-based sustainability indicators were carried out on the Elasticsearch interface, Elastic Stack 7.5.0 version.

While the oldest version of the reviewed tool was designed in 2001, the latest version of the tools was modified in 2019. The categorization of the indicators and sub-indicators into categories and hierarchies varies across the tools. The adopted indicators and sub-indicators amongst the tools also diverse, with the indicators ranging from 8 to 39 while that of the sub-indicators is from 0 to 69. While some of the tools were designed solely for indicators, others are established with the classification of the indicators into categories. The remaining further sub-divided the indicators into sub-indicators. However, it was observed that one of the tools was designed as a questionnaire survey classified into seven categories. There are 55 categorizations of indicators across the 13 tools, of which no single categorization was used in all the tools, and more than ten categories were used in only one tool. These findings vividly show a lack of uniformity in the categorization of indicators across the CSA tools. Similar variations are observed in the adopted indicators and sub-indicators. This finding is interesting because most of these tools are developed and utilized mainly by higher education campuses in developed countries with closely related values. These variations were perceived in this research to be due to the tools' differences in scope as well as accessibility and availability of data on selected indicators. The comprehensive review of the 13 tools reveals that the majority of the tools are establishment based on the availability of sustainability indicators for the appraisal process and not on the basis of public participation via social media. Although two of the tools invited local experts' contributions in selecting indicators for these tools, only one reported that eight local experts were involved, which is small and cannot be regarded as representative enough.

The filtering process towards identifying peculiar sustainability indicators for establishing the appraisal model and evaluation started with removing all indicators and sub-indicators with their categories that are not campus-wide, spatial and environmental in nature. This led to the reduction of the attributes to 13 categories, 50 indicators, and 66 sub-indicators. At the end of this stage, there are campus-wide, spatial-based, and environmental indicators that could (i) not be measured, (ii) repeated across the tools, and (iii) too generic and complex for sustainability appraisal.

This led to another round of filtering that reduces the categories to seven (i.e., operations, environment, setting and infrastructure, energy and climate, waste, water, and transportation) and 29 indicators. After identifying indicators that are in line with this study's scope, the indicators were then validated in the case of HEIs in Nigeria. Rather than relying on validation of the indicators by consulting members of Nigerian university management, administrators, or local experts in the area of a sustainable campus, validation based on social media was utilized in this study.

When the seven categories were used as keywords to determine their peculiarity with Nigeria's situation, six unique categories were finally identified. They are (1) environment, (2) infrastructure, (3) energy, (4) waste, (5) water, and (6) transportation. On the other hand, the 29 indicators were reduced to 11 unique indicators peculiar to HEIs within Nigeria's context. The data from Twitter social media shows that the HEIs stakeholders in Nigeria did not discuss and pay attention to the issue of campus operations, settings and climate.

The research outcomes reveal that some indicators which relate to the planning and management of campus functions and space, thus have a spatial dimension. It indicates how GIS and 3D modeling software can assist in measuring the spatially-related indicators that have been compiled from the 13 existing CSA tools and validated to the case of Nigerian HEIs.

8.3 Research Significance and Contributions to knowledge

8.3.1 Social Media UGC to CSA Research

Social media has completely changed the way people communicate within the last decade. Different social media platforms provide a massive volume of information, which has led to a new research field known as big data. Researchers are now relying on a large amount of data from various social media channels to conduct social science projects rather than wasting substantial financial cost and time on ethnographic trips, questionnaire surveys, or interviews. This reliance on social media is because it is currently the most preferred means of communication which do not restrict the users the expression of their feelings within their comfort zones and available time, unlike conventional survey and interview that will require that the interviewer book an appointment with the interviewees or infringe on their privacy and busy schedule. At present, virtually everyone with access to the internet has at least a social media platform for interacting with family and friends, colleagues, groups, news channels, organizations, politicians, and institutions administrators.

Moreover, social media is now gradually eliminating print media, television channels, and other media channels. There are currently more than 2.82 billion of the world population with internet service on social media, making social media one of the highest means of communication and online information sharing (Pitrov & Krejˇ, 2019). The increase in social media use can also be related to the wireless internet connection to tablets and smartphones, which are easy to move around and quickly accessible, unlike laptops, personal computers, and desktop computers. The connection of the internet to different devices is no more a daunting challenge in the current age and time in most developed and developing countries of the world.

Social media is now transforming communication from physical (face to face) interaction to virtual interaction on different electronic gadgets. The dramatic decrease in the price of electronic gadgets and a corresponding increase in the performance of software/hardware, wireless connection, computer processing unit, and application that is being witnessed across the globe have given rise to the concept of social media big data analytics and artificial intelligence. This advancement in software performance has also led to the implementation of social media-based projects in various fields like transportation, e-tourism, e-commerce, and construction and environment. Presently the vast volume of social media data mined by different researchers, analytic companies, and institutions are much easier to clean, filter, and interpreted in different cloud storage environments to bring about new services or approaches to conduction business or designing transportation route, etc. These discoveries emanating from the use of data from social media is opening new commercial, investment, sustainable planning, and construction opportunities. The era of experiencing difficulties with the storage of a considerable volume of social media UGC is gone. Several cloud storage environments can be utilized for free or via the payment of subscription fees. Now, the vital aspect of social media big data research is the development of models, frameworks, or logical approaches towards efficient utilization of the data to bring out excellent outcomes.

There is a high tendency for the adoption of social media data in several fields to escalate in the nearest future. A comprehensive review of literature on tools and frameworks for assessing sustainability for QOL in HEIs across the globe reviews that the utilization of social media data is lagging. Studies conducted by Carpenter et al. (2016) and Hamid et al. (2017) recommended the promotion and the awareness of social media roles in higher education sustainability. This study contributed significantly to the identified knowledge gaps in the existing literature. It advanced the studies of environmental sustainability dimension with spatial-based indicators in Nigeria higher education with the incorporation of social media data. It was observed that despite the involvement of local experts in the process of indicators selection by two of the existing CSA tools, none utilized the social media data, big data analytics tools, and comprehensive coverage of local stakeholders in HEI in arriving at the selection of sustainability indicators for their appraisal process. Currently, there are several conferences, workshops, and seminars on several social media research outcomes. Although there are difficulties with using social media data for conducting different nature of research, the most prominent one is the trade-off between privacy and utility. The difficulties of accessibility and privacy were eliminated in this study by obtaining a Twitter developer account application and using a Python 3 library in addition to complementary codes/command lines for accessing old Twitter data.

8.3.2 Elastic Stack to CSA Research

The three powerful online open-source software for a massive volume of data analysis from single or multiple sources, which are (i) Elasticsearch, (ii) Logstash, and (iii) Kibana, are jointly referred to as Elastic Stack. Each can work independently but more reliable and efficient when incorporated together. The Elastic stack is designed to work as software as a service, but it can also be used on other premises/platforms (Bajer, 2017). The first plugin-based which is known as Logstash, is designed to mine different or single data source in the form of HTTP API, CSV file, etc. at once and or at the same time; thereafter, modify and transfer the data to other software, devices or plugin-based features (Bajer, 2017). The mining and transformation are usually in a three-phase process of (a) inputs, (b) filters, and (c) outputs.

In most cases, the filtered data are shipped to Elasticsearch despite having the power of sending the processed data to other databases or analytics algorithms. The second, called an Elasticsearch, performs simple and or complex search operations such as query in newline delimited JSON, statistical, and CRUD (create, retrieve, update and delete) operations. The third powerful tool, called Kibana, is a visualization internet-based platform for analyzing, searching, and viewing data that are contained in Elasticsearch assemblage.

In summary, Logstash can be referred to as a collecting and parsing tool; Elasticsearch, a storage and searching tool, while Kibana is a visualizing tool. A fourth product known as Beat has been recently added to the stack. A comprehensive review of the literature shows that the integration of substantial open source and commercial data sources, user-generated content on a various online platform, Internet of Thing (IoT) data, energy data, and open government data via the use of Elastic Stack for resolving different commercial and development projects have been conducted. Findings from this comprehensive research review reveal that the utilization of these three online tools and technology is lagging in the projects, studies, and research on CSA. None of the 13 CSA tools reviewed in this study utilized this software in mining, filtering, or visualizing social media data for conducting and implementing sustainable or green campus research. As such, the utilization of these powerful open software tools serves as another significant contribution to knowledge gaps in CSA research.

8.3.3 Weighting Methods to CSA Research

Weighting has been recognized by many scholars and practitioners as an integral component in the design of sustainability appraisal tools (Cole, 1999). It serves as the foundation of appraisal systems due to it dominance on the general assessment (Lee et. al. 2002). The incorporation of the weighting scheme into the framework of an appraisal tool improves its efficiency for utilization in different parts of the world (Alyami and Rezgni, 2012; Ding, 2008). However, despite the usefulness of weight allocation in regards to the sustainability indicators performance assessment, there is no consensus on the approaches/methods for allocation of weights and relative importance to sustainability indicators (Ding, 2008). The review reveals variations in the approaches to assigning weights to the selected indicators of the selected tools.

However, none of the extant literature review articles has specifically reviewed the coverage of various weighting methods in the existing tools of campus sustainability assessment. This article reviewed 12 existing campus sustainability appraisal tools to analyze the utilized weighting methods. The outcomes of the review show that the analytic hierarchy process (AHP) is the most suitable method for the appraisal process in HEIs due to its usage simplicity, flexibility, and small expert size utilization with high consistency ratings.

8.4 Study limitations

A concern with the use of social media analytics and the comprehensiveness of the study findings regarding the number of social media users in the campuses, criteria for selection of campuses, etc., was raised by some experts during the framework validation stage. Social media use in Nigeria is not extensive and can be highly subjective. They opined that beyond perception studies, any social media linkages to the study focus would be arduous. They also claimed that anecdotal evidence points to the fact that the Twitter conversations relevant to spatial planning and environmental conditions in HEIs in Nigeria are usually complaints. A campus appraisal framework cannot rely on social media data alone. It will be most beneficial if it incorporates both the social media mined data (for perception analysis and perhaps establishing areas of concern) with primary data collected at the source (for objective appraisal). The various universities' Works and Physical planning units, responsible for ensuring planning and environmental sustainability standards, should be interfaced in future studies.

One of these study’s methodology design limitations is the adoption of Mangold Fauld’s social media categorization. Future studies may consider modifying social media microblogs' categories with the current advancement in social media platforms while exploring social media utilization in CSA tools. One limitation is the computer skills required to build the system in addition to workforce skill training. The accuracy of data entry and manipulation can also affect the outcome. However, the framework is flexible, and future research using the proposed framework can modify the approach.

In limiting the study's based case, coverage, and content analysis to only published literature on Campus Appraisal, it is assumed that this study left out a vast resource that can be found in grey literature that may not be publicly available on the internet, as well as engaging with the subject of his study – the HEIs themselves.

There are several challenges and criticism of the philosophical approach of symbolic interactionism in the extant literature. Writers such as Fine, (1993) maintained that the theory of symbolic interactionism does not apply the scientific method in its approach and cannot comprehensively address the challenges of macro sociology. He believes that the philosophical approach of symbolic interactionism is mostly limited to the field of sociology and social psychology. Fine, (1993) also claimed that the theory is not sociological and that the majority of the scholars that are concerned with this theoretical approach only engage in agentic choices that have received a lot of condemnations. The criticism of symbolic interactionism from the perspective of the post-modernism and some other theorists is that its data and collection strategies are perceived as a second-order reality, discursive and should be dissolved and questioned continuously (Clough, 1989; Schneider, 1991).

When criticizing the theory of symbolic interactionism on its level of policy relevance, Fine, (1993) claimed policymakers view its conclusions with a lot of skepticism. This is a result of the fact that symbolic interactionists tend toward the avoidance of the techniques of statistical methodology, as such their data will contain several biases and should not be trusted. Other critics of symbolic interactionism argued that the proponents of the theory lack a clearer ability to systematically explain the theory's philosophical approaches and concepts. They explained that only George Herbert Mead's teachings (with several inconsistencies and imprecision) were continuously disseminated for several decades until it was eventually compiled by Herbert Blumer in 1973 into a print clarification format.

In response to some of these general criticisms of symbolic interactionism, the adoption of this philosophical approach can be successfully used in mining social media big data (using social media symbols) from multiple platforms in a systematic way that will ensure that human preferences toward campus sustainability are obtained. Thereafter, machine learning, artificial intelligence, and sentiment analysis could be carried out to the perception of human behaviors and all related challenges of sustainability within tertiary institutions campuses can be assessed. Blumer responded to some of the critics of this theoretical approach that symbolic interactionism is not a method but rather a philosophical approach (Blumer, 1969). Also, the philosophical approach of symbolic interactionism is not limited to the field of sociology and social psychology but rather it has been expanded into several other theories like the theories of the development of civilization (Couch, 1984), critical theory, chaos theory (Young, 1991), Parsonian theory. Symbolic interactionism has also been incorporated with cultural studies and several adoptions of the theories have been identified in extant literature (Fine, 1993).

The concept of symbolic interactionism places high attention on human social interaction including the interactions taking place on various social media platforms. It should be recalled that the field of urban planning or campus planning is not entirely a social science domain. The majority of scholars in the field of urban and regional planning mostly adopt a holistic approach toward the assessment of the challenges in urban areas and HEIs campuses as well as the comprehension and interpretation of human behaviors and attitudes. Therefore, one should expect that the philosophical approaches to researching the area of campus planning and appraisal should include pertinent research areas like medical, bio-chemical, psychological, physiological, and social science research areas. A better and clearer understanding of human perception, preferences, level of importance, and behavior toward the higher institutions campuses could be carried out with the adoption of the philosophical perception of symbolic interactionism. However, it is currently not sufficient to extensively expand campus planning and sustainability appraisal.

Concerning CSA research, one of the limitations that can be attributed to this theory is that it does not place enough emphasis on the element of human behaviors that have to deal with unconsciousness and emotions. As such it will be difficult to examine the emotion behind the comments of social media users concerning the concept of campus sustainability that is being extracted from the various social media websites. Also, one of the premises of the theory is that "an individual's roles change constantly" (Shalin, 1984 p.544). This can be referred to as another limitation of adopting this philosophical approach because it will create room for critics to question the validation and the conclusion of studies on CSA. In a situation where the role that different individual and HEIs stakeholders' play in making comments, sharing opinion and participating actively in discussing what a sustainable university campus should look like or the sustainability indicators that should be given higher preference continuously change from time to time, this might throw some level of skepticism into the outcome of such research. However, in this research, these limitations are perceived as strengths and justification for incorporating this approach because there is a need for modification and continuous review of the appraisal process. Although, the philosophical perspective of symbolic interactionism can contribute significant insight to sustainable campus appraisal and human behaviors, several other measures, and perspective in ensuring holistic appraisal research are still needed.

8.5 Direction for future research

Lastly, citizen participation options are available in ESRI's spatial technique platforms allowing for a participatory appraisal mechanism. The public participation platform options have not yet been utilized in CSA despite their potential in advancing the process of developing and selecting indicators.

Future research should utilize sentiment analysis based on the latest machine learning technology to ascertain the orientation (i.e., positive, neutral, or negative) of the identified attributes. The machine learning technology could also be utilized in understanding the behaviors within HEIs based on the identified campus sustainability attributes. Future studies utilizing the study's framework and the proposed theoretical basis should be extended to all HEIs in Nigeria and the global south.

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