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Campus Sustainability Appraisal in Nigeria: Setting up Sustainable Attributes for Higher Educational Institutions

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1 ABSTRACT

Sustainable campus development has gained the attention of several policymakers and urban planners within the past decades with different campuses across the world claiming to be sustainable or have adopted initiatives of becoming sustainable. The different tools for assessing sustainability in higher education cannot be utilised in all institutions across the globe due to factors such as regional variation. This paper established and formalised a systematic approach to comprehensively review sustainability indicators identified in 13 campus sustainability assessment tools. Thereafter, Twitter social media and an online big data analysis tool were utilised in selecting environmental-based sustainability indicators for higher educational institutions in Nigeria. The rise in the use of social media amongst tertiary institution stakeholders ensures that a better understanding of environmental challenges can be derived from the perspectives of these stakeholders. The findings from the comprehensive review of the selected 13 tools reveal that there are variations in the sets of their sustainability indicators and selection process. None of the tools have compatible indicators for campus sustainability appraisal and none of the tools utilised social media and big data technology to arrive at the adopted set of indicators for their appraisal framework, threshold, and rating. We identified energy, environment, transport, infrastructure, waste, and water as the major categories for sustainability indicators in Nigeria. The current research gap identified from literature strongly justifies the purpose of this study that setup sustainability indicators that are peculiar to tertiary institutions in Nigeria that will bring about an appraisal framework and also give room for campuses to compare their sustainability performance and interchange of standard practices.

Keywords: Elastic stack, Campus sustainability, Social media data, Nigeria, Sustainability indicators

2 INTRODUCTION

For several decades, campus sustainability appraisal (CSA) has been identified as a paramount initiative in different academic disciplines such as urban planning, urban design, environmental design, landscape architecture, social sciences, and others. Research on CSA differs based on methodology, aim, objectives, nature of the study and the local conditions of the location where it is being carried out. Different researchers in academic fields have an interest in multiple aspects of CSA, therefore its implementation has been initiated, conceived and measured differently over time. While some scholars are interested in the appraisal of sustainability courses in tertiary institutions' curriculum, research, scholarships, and campus operations; others are paying attention to sustainability accounting and outreach to the larger society. According to Sonetti et al. (2016), CSA "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. A sustainable university is defined by Velazquez (2006) as ‘‘a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimisation of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles“p.30.

Different scholars at university, non-governmental, country-level in addition to the United Nations Environment Programme (UNEP) have established toolkits, ratings, models, frameworks for CSA as a tool to evaluate the level of environmental, social, economic and institutional sustainability in higher educational institutions (HEI) campuses. In such an appraisal, the first task is usually the identification of the various dimensions and attributes of the CSA in HEIs settings. In general, the CSA attributes are categorised into main criteria, sub-criteria, and indicators. The hierarchy and number of CSA criteria and indicators specified and addressed in different tools are numerous and differ from framework to framework. However, despite various definitions of CSA, a larger percentage of researchers in the area of campus sustainability tend to always conduct their studies with the approach that the CSA framework is multidimensional. They also agree that CSA tools have subjective and objective attributes and that these should serve as the foundation of CSA as a whole.

CSA studies in HEI campuses have been driven by the United Nations Environment Programme, Education for Sustainability Development Innovations Programmes for Universities in Africa (Lotz-sisitka 2013) and many more. This trans-continental, extensive development and utilisation makes the CSA an effective, useful and practical approach of measuring and rating the impact of campus developmental and sustainability policies. As a result, CSA can be referred to as a pragmatic tool that gives a broad base of information for HEIs authorities, administrators, campus planners, and local policymakers. For instance, the outputs of CSA exercise can be utilised by HEIs policymakers to evaluate the accomplishment of their policies and action plans. The appraisal of sustainability at the HEI level can also be perceived as a way of monitoring changes in HEI stakeholders' view of the level of importance for improving campus life and direction for future development in developing nations like Nigeria.

Nigeria is a country located in West Africa with huge crude oil and gas reservoirs and is among the countries with the highest Gross Domestic Product (GDP) in Africa. The country was transformed from an underdeveloped sub-Saharan African country to a powerhouse in Africa mostly due to huge revenue from the sales of crude oil. The spontaneous development of university campuses to meet the demand of the huge population of the country and the migration of people from the hinterland to the urban centre for the acquisition of higher education degrees had led to the difficulties of initiating and implementing new and adequate facilities and infrastructure. These challenges have been creating some significant impacts on the people residing within these HEI campuses and their environs. Urban planners and government officials have been formulating plans and policies to curb these challenges without any significant improvement leading to the need for CSA research. In approaching these challenges, there is a need for the establishment of an assessment tool/framework for the appraisal of campus environmental development within the HEI campuses in Nigeria with a corresponding policy manual on campus environmental sustainability. To achieve these enormous tasks, there is a need for setting up sustainable appraisal indicators that are in line with the situation on campuses within Nigeria.

Despite the high investment in planning, designing and establishment of HEI campus across the geopolitical zones in Nigeria, there is an absence of metrics to appraise the environmental sustainability of these campuses for adequate quality of life. A comprehensive review of the literature reveals that studies using social media data and or big data analysis tool to ascertain the peculiar sustainability indicators of the region where CSA techniques are being implemented has not been conducted before. Despite the focus of some of the targets of the Sustainable Development Goals (SDGs) on information and communication technology (ICT), it can be observed that this has not been fully implemented. This study utilised a technology-driven (open-source software and social media data) methodology that bridges the gaps in existing research and produces an outcome that has the potential of ensuring liveable campuses and cities for all. The findings of this study are also very useful for all professionals in the built environment as well as researchers in the area of sustainable and green campus planning. It will also serve as the foundation for studies, projects, and research on CSA in Nigeria HEI campuses.

3 LITERATURE REVIEW

3.1 Social media Data and Campus Sustainability Appraisal Research

The social media has completely changed the way people communicate within the last decade. Different social media platform provides a huge volume of information which has led to a new field of research 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 huge financial cost and time on ethnographic trips, questionnaire survey or interviews. This is because the social media 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 encroach 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, organisations, politicians and institutions administrators.

Moreover, social media is now gradually eliminating the 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 sharing of online information (Pitrov and Krejˇ 2019). The increase in the use of social media can also be related to the wireless internet connection to tablets and smartphones which are easy to move around and easily 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.

The 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 has also led to the implementation of projects in various fields like transportation, e-tourism, e-commerce and construction and environment. Presently the huge volume of social media data mined by different researchers, analytic companies and institutions are much easier to clean, filtered and interpreted in different cloud storage environments to bring about new services or approaches to conduction business or designing transportation route, etc. These new 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 huge volume of social media is gone as there are several cloud storage environments that can be utilised for free or via the payment of subscription fees. Now, the vital aspect of the social media big data research is the development of models, framework or logical approach towards efficient utilisation of the data to bring out excellent outcomes.

In the nearest future, there is a high tendency for the adoption of social media data in several fields will escalate. A comprehensive review of literature on tools and framework for the assessment of sustainability in HEIs across the globe reviews that the utilisation 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 sustainability in higher education. This study seeks to bridge this gap identified in the existing literature and advanced the studies of environmental sustainability in Nigeria higher education with the incorporation of social media data. Currently, there are several conferences, workshops, and seminars on several social media research outcomes. Although, there are difficulties with the use of social media data for conducting different types 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 as well as the use of a Python 3 library in addition to a complementary codes/command lines for accessing old Twitter data.

3.2 Elastic Stack for Campus Sustainability Appraisal Research

The three powerful online open-source software for a huge 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 a 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. once or simultaneously; and thereafter, to modify and transfer the data to other software, devices or plugin-based features (Bajer 2017). The mining and transformation of data takes place 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 database or analytics algorithms. The second which is 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 visualisation internet-based platform for analysing, 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 visualising 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 huge open source and commercial data sources, user-generated content on a various online platform, Internet of Thing (IoT) data,

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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 review reveal that the utilisation of these three online tools and technologies is lagging in the projects, studies, and research on CSA. None of the 13 CSA tools reviewed in this study utilised this software in mining, filtering or visualising social media data for conducting and implementing sustainable or green campus research.

3.3 Measuring Sustainability in Campuses: Indicators and Categories

Although there are several appraisal tools for measuring the level of sustainability in different parts of the world, it has been observed that a common approach of assessment exists among these tools. Assessment via the use of indicators remains the most widely adopted approach by many scholars in the field of sustainability in higher education (Alshuwaikhat et. al., (2017). CSA indicators can be regarded as the paramount component to be considered when conducting an appraisal of HEIs sustainability performance. This is due to their provision of reliable, useful and relevant information on specific attributes of HEI campuses. However, virtually all the CSA tools have a framework that is based on hierarchy in such a way that assessment indicators are categorised under criteria, dimensions, modules, aspects, principles, strategies, etc. A comprehensive review of 13 documents of the existing CSA tools reveals that there are diverse approaches to classifying the adopted indicators into a hierarchy. Findings show that three CSA tools adopted the criteria approach, five adopted the categories approach, two adopted the strategies approach and the remaining adopted the module, dimension, and principle approach each. In addition, a review of several works of literature on the subject of sustainability in higher education also shows that different scholars come up with a diverse classification of assessment tools into indicators as well. For instance, (Alghamdi et. al., (2017) adopted the hierarchy of assessment tools into criteria.

Also, there are multiple approaches that have been adopted by scholars in selecting suitable indicators for the development assessment tools for appraisal purposes. The two most widely adopted approaches are theory-driven and data-driven. Other approaches include but are not limited to policy-driven, reference values for indicators, ecological-based and spatial based indicators (Niemeijer 2002). The theory-driven approach to selecting indicators for sustainability assessment is based on the selection of sustainability indicators that are in line with a certain philosophical approach or theoretical framework. On the other hand, the data-driven approach is based on the availability and ease of accessing reliable and relevant sustainability data. It was discovered that the most widely adopted approach is data-driven.

A comprehensive review of 13 CSA tools shows that seven of these tools did not provide an explanation of the selection criteria for the adopted indicators. One of the tools adopted a subjective view of what the developers of the tools feel appropriate for sustainability in higher education with yearly modification. Another arrived at the adopted sustainability indicators for their tools by modifying the sustainability indicators contained in the Global Reporting Initiative (GRI) Sustainability Guidelines and thereafter validate the selected indicators at workshops on sustainability in higher education. The remaining two CSA tools conducted a comprehensive review of existing tools to extract sustainability indicators, thereafter adopted and developed a convenient filtering process for the selected indicators. After the filtering process, their final selection of indicators was concluded with the local expert analytic hierarchy process (AHP). It was observed that despite the involvement of local experts in the process of indicators selection by two of the existing CSA tools, none utilised the social media data, big data analytics tools and wide coverage of local stakeholders in HEI in arriving at the selection of sustainability indicators for their appraisal process. As such this study was designed to fill the existing gap in the literature. The next section presents the methodology adopted for this research.

4 METHODOLOGY

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, the selected tools for this study were selected based on the following criteria: (1) they are all available in the English language and easily accessible on the internet. The tools that were identified but not written in English such as one developed by the German Commission for UNESCO was 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 utilised in HEIs. These tools are mostly 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 tools that are online-based or well-known (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 that are 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 (see Table 1). Thereafter, the indicators were subjected to exclusion criteria to ensure that the indicators that are only relevant 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 is because HEIs campuses in Nigeria have substantial geographical areas (Adeniran, 2015; Adeniran, 2014) with severe impact and certain 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.

CSA Tools	Version Reviewed	Categories	Indicators	Sub-indicators
Sustainability Assessment Questionnaire	2001	7	-	-
Graphical Assessment of Sustainability in University	2006	4	8	59
Sustainable University Model	2006	4	23	-
University Environmental Management System	2008	3	8	23
Assessment Instrument for Sustainability in Higher Education	2009	5	30	-
Unit-based Sustainability Assessment Tool	2009	-	9	-
Three dimension University Ranking	2009	3	15	-
DPSEEA-Sustainability index Model	2011	5	20	56
Graz Model for Integrative Development	2012	5	15	-
Sustainable Campus Assessment System	2013	4	25	34
Adaptable Model for Assessing Sustainability in Higher Education	2014	3	9	25
UI’s GreenMetric University Sustainability Ranking	2019	6	39	-
Sustainability Tracking, Assessment and Rating System	2019	6	19	69
Total		55	220	266

Table 1: Overview of the 13 CSA tools analysed in this study

The stage that follows merged all the repeated indicators and then structured the reduced lists into only two hierarchies. This was done to eliminate the challenges of users of the proposed appraisal model of not being able to understand or utilise 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, the authors carried out minor changes although the categorisation adopted in the 13 CSA tools was taken into considerations. The uniqueness of each sustainability indicator was investigated based on their operational definitions. This was considered to eliminate the challenges of differences in defining and measuring the indicators across the selected tools. Finally, the remaining indicators that are in line with the scope of the study were used as keywords to filtered the Twitter social media data that were 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 utilised to extract tweets from Twitter via Twitter Application Programming Interface (API). After several attempts without substantial 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. Thereafter, Python 3 library was utilised 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 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 the identification of indicators for sustainability peculiar with Nigerian HEIs, the approach adopted at this stage of the study is the identification of tweets that contain the environmental-based sustainability indicators that are line with the scope of this study. The final filtering/selection process in ensuring that only tweets containing the targeted indicators were carried out on the Elasticsearch interface, Elastic Stack 7.5.0 version.

5 RESULTS AND DISCUSSION

Table 1 shows the displays of the breakdown of the selected 13 CSA tools. While the oldest version of the reviewed tool was designed in 2001, the latest version of the tools was modified in 2019. The categorisation 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 from 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 categorisations of indicators across the 13 tools of which no single categorisation was used in all the tools and more than 10 categories were used in only one tool. This vividly shows a lack of uniformity in the categorisation 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 utilised mostly by the campuses of higher education in developed countries with closely related values. The authors are of the view that these variations are 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 the selection of indicators for these tools, only one reported that eight local experts were involved which is small and cannot be regarded as being representative enough.

The filtering process towards the identification of peculiar sustainability indicators for the establishment of the appraisal model and evaluated 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 the identification of indicators that are in line with the scope of this study, the indicators were then validated to the case of universities 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 utilised in this study. When the seven categories were used as keywords to determine their peculiarity with the situation in Nigeria, 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 the context of Nigeria. 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. Table 2 shows 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 modelling 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.

	Category	Indicator	Role of Spatial-based Software in Indicator Measurement
1	Energy	Energy consumption	quantity of electricity per source, area and percent of buildings that generate greenhouse gases
		Greenhouse gas emissions	
2	Environment	Open space area	area and percent of land use, acreage of green area, acreage of landscape area
		Forest vegetation	
		Landscape	
3	Infrastructure	Buildings	area of buildings
4	Transportation	Campus fleet	length of walkways, bicycle lane, and communication route
		Pedestrian and cycling	
5	Waste	Waste management	quantity of waste per source
		Sewerage disposal	
6	Water	Water consumption	quantity of water per source

Table 2: Spatially related indicators for assessing campus environmental sustainability

6 SPATIAL-BASED INDICATORS IN THE CASE OF NIGERIA

The use of campus-wide, environmental and spatial-based indicator framework in the case of Nigeria will provide 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 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 HEI campuses across the country are becoming the centre of attention due to an increase in demand of staff and students, energy, waste generation, housing, etc.

Given the national increase in the number of universities and colleges in Nigeria between 1990 to 2015, many considered HEI campuses to be the epicentre 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 to shift the focus of their development and assessment to a spatial-based model.

In Nigeria and other developing countries, access to data is very difficult, thus undermining the conduct of sustainability assessment. After review of literature, it became apparent that there is no use of 3D and spatial-based technology by decision-makers to assess campus sustainability as well as the creation of a more sustainable campus policy based on those assessments. However, with regards to measuring the indicators for environmental sustainability and conducting the assessment, the GIS-based approach can play a vital role. 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. As such, a Cityengine and other conventional 3D modelling software database should be developed for the indicators after which sustainability assessment can be easily conducted. When remote sensing images are incorporated into the 3D modelling software database, it can facilitate the extraction of data from satellite sources. These spatial data can then be used to measure some spatially-related indicators. Because indicator selection is context-dependent. In this study, the selected indicators are prioritised due to local context via the use of Twitter social media.

7 CONCLUSION

This paper established and formalised a systematic approach to comprehensively review the level of sustainability indicators identified in 13 CSA tools. Thereafter, Twitter Social Media and an online big data analysis tool (Elastic stack) were utilised in selecting environmental-based sustainability indicators for universities in Nigeria. The findings from the comprehensive review of the selected 13 CSA tools reveal that there are variations in the sets of their sustainability attributes and selection process. None of the tools have compatible attributes for campus sustainability appraisal and no different tools can assess the level of sustainability across university campuses with the same appraisal framework, threshold, and rating. This strongly justifies the purpose of this study that calls for the adoption of setting up of environmentally-based sustainability attributes that are peculiar to the geographical locations with similar challenges and requirements that will bring about an appraisal framework that gives room for campuses to compare their CSA performance and interchange of standard practices.

The outcomes of this study have some pragmatic implications for scholars in the field of CSA. It also reveals how projects dealing with the identification, setting-up and developing CSA in developing and developed worlds can be enhanced. Firstly, this study shows that CSA attributes should focus more on the needs, preferences and the level of importance that the stakeholders within which the appraisal will be conducted rather than a comprehensive or long list of indicators based on developers' opinion. The comprehensive review of the 13 CSA tools reveals that there is no strong justification between the set of attributes adopted by each of the tools and their corresponding scope (the local area where it will be implemented). Findings from the literature also classify CSA tools with a long list of sustainability attributes as being complicated and difficult to use for users. Hence, this study established well-balanced sustainability attributes that are peculiar to the end-users and their campuses.

Secondly, the hierarchy of the CSA framework should not be extensively long and detail. Two-level (i.e., categories and indicators) makes it convenient and efficient to conduct a level of importance of the attributes using approaches such as the AHP and social media-based campus sustainability indicators preference model. Multiple levels will make the assessment process become complicated and difficult for adoption by other scholars. Thirdly, scholars conducting the setting-up of CSA attributes should ensure that a wide range of all environmental and spatial-based sustainability attributes was first considered before finalising the final set of indicators that meet the need of their study's scope, aim, and objectives. Selecting the adopted indicators without an initial full range coverage might introduce some scepticism in the final output of the appraisal.

Another finding of our research that has implications for CSA studies is the fact that setting-up or establishing a set of CSA indicators to be adopted for the specific geographical unit does not necessitate the development of a completely new set of indicators. Rather, they should be established by studying a comprehensive list of existing attributes and modify them to suit the new scope based on the requirements of that geographical region. How GIS, City Engine, and 3D modelling software based sustainability assessment for academic campuses and demonstrating its uniqueness as compared to other campus sustainability assessment frameworks and approaches was also discussed. For the said purpose, Geographic Information Systems will be used to develop a campus sustainability model within its sphere of operations. The use of GIS and CityEngine is primarily due to its application and ability to incorporate huge datasets within its program. Secondly, it has made more infiltration, than any other spatial application due to the increased awareness among policy and decision-makers to rely on these systems for public policy formulation. GIS, a computer-based system, can process the data from a variety of sources and integrating it with the geographical location while providing the user or the decision-maker with the information necessary for making informed decisions (Han and Kim 1989).

Lastly, the outcomes of this study show the importance of utilising social media data and Elastic Stack as a reliable, more efficient and intelligent way for selecting and setting-up CSA indicators for university campuses in both developed and developing countries. The approach as well as the findings of this research display paramount contributions that bridge the identified knowledge gap in the literature.

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