



## RELEVANCE OF GIS IN OPERATING A SMART CAMPUS FOR A SUSTAINABLE LEARNING ENVIRONMENT IN TERTIARY INSTITUTIONS: A REVIEW PAPER

<sup>1</sup>S. K. Aroge\*, <sup>2</sup>J. S. Adeleke, <sup>1</sup>W. P. Suru., <sup>1</sup>F. G. Odeyemi and. <sup>3</sup>B. E. Adewole

<sup>1</sup>Department of Surveying and Geo-informatics Federal Polytechnic Ede, Nigeria

<sup>2</sup>Department of Building Technology, Federal Polytechnic Ede, Nigeria

<sup>3</sup>Department of Surveying and Geo-informatics, Federal University of Technology Akure, Nigeria

Corresponding author email: [kayodearoge2000@gmail.com](mailto:kayodearoge2000@gmail.com)

**Abstract** - *The recent (COVID19) pandemic is an eye opener for global tertiary institutions towards the integration of smart campus, where a lot of activities needed to be carried out are done remotely in order to curb the spread of the disease. Smart campus has proved to be a new technology for institutions of all various categories to improve in their acquisition of knowledge, methods of making decisions and creating a sustainable campus in order to provide a suitable and stress-free learning environment for students and staff of every school. In order to eliminate the conventional method of learning that are common in most academic institutions, this paper explores the relevance of GIS in operating a smart campus for a sustainable learning environment in institutions. In order to achieve the aim of this study, a systematic literature review method was adopted by downloading twenty two top and recent articles on smart campus using Google search engine to access different free online journals. Eight journals relating to the study were carefully selected and reviewed after thorough screening of the twenty two numbers of journals downloaded online. The study developed a framework suggesting that GIS tool remains a major and integral tool in operating a smart campus, having its relevance in the area of technology, facilities and environmental sector of a sustainable smart campus which could assist in the enhancement of proper management, monitoring, access to information and prevention from losing acquired data unnecessarily and above all for connectivity. Thus, the paper recommends that the GIS tools is still very much underutilized in the development of smart campus, emphasizing that GIS technology still has a lots of peculiarities in areas of environment, facilities and technology to human daily activities in operating a successful smart campus.*

**Keyword:** *GIS, Smart Campus, Limitations, Sustainable Learning Environment, Institution*

### 1.0 Introduction

The recent (COVID 19) pandemic had necessitated the need for a paradigm shift, which predominantly is characterized with virtual teachings and remote working in tertiary institutions (Rahim *et al.*, 2021). In recent years, technological advances had enhanced education institutions to a new height, where some universities can't afford to upgrade their learning facilities (Soria *et al.*, 2013), the increase in the development of intelligent technologies proffer opportunities for various objects in the real world to communicate with the use of sensors and other communication networks (Nachandiya *et al.*, 2018). Smart Campus has emerged as an significant concept and alternatives of advancing technology in educational institutions (Karam *et al.*, 2020). This also creates an environment for learners, teachers and learning devices to interact in any learning process (Gambo, 2017; Klimova, 2016). A smart campus had been described as a subset of smart city that involves the intergration of various modern technologies such as sensors, internet of things (IoT) and cloud computing among others, which is aimed at providing a suitable and smart environment that will enhance an effective communication among students, teachers and administrators.(Kumar, 2017; Jianqing *et al.*, 2014). The idea to develop a smart campus is to reduce the difficulty and challenges commonly faced by students and every staff and visitors of an institution by providing easy access to information, reduced risk of losing information when moving files around, reduction in stress and time for achieving a predetermined task, adopting more of remote sensor in achieving activities than the physical or conventional methods. Nachandiya *et al.*, (2018) listed the features that could made up a sustainable smart campus which includes the list of various installations of customized tablets, interactive boards, sensors, mobile devices, touch boards, interactive projectors, Wi-Fi, Pana-Boards and CCTV.

All these features are capable of providing a sustainable learning environment in campuses (Nachandiya *et al.*, 2018). Institutions in developing countries still operate using the traditional method of teaching and keeping of records through the file based system. This process is always inconvenient and time consuming for both the students and the lecturers, it exposes both party to loss of vital information and insecurity of having little knowledge about their premises and lastly, the recent (Covid 19) pandemic lead to total shut down of academic activities in all institutions in the region. There is an urgent need for an informative innovations that would support smart learning, embrace new technologies and encourage uninterrupted learning opportunities in a smart campus environment (Kinshuk *et al.*, 2016). Thus, this paper carried out a comprehensive review and analysis of articles published on smart campus bringing out the relevance of GIS in operating a smart campus with the intention of providing information on the level of adoption of GIS application in operating a smart campus and further expresses and deepens areas of integration of GIS application in order to enhance a more smarter and sustainable environment in higher institutions.

## 2.0 Methodology

The method adopted in this paper involved downloading top and recent articles on smart campus using Google search engine to access online journals. Eight journals out of twenty two journals relating to smart campus was carefully selected and reviewed and after thorough evaluation of the twenty two numbers of journals downloaded online. The eight journals finally selected were used as a data for this paper and were reviewed in a tabular form as shown in table 1.

**Table 1: List of Relevance Articles in Operating a Smart Campus, Contributions and Limitations**

Author	Topic	Method and Results/Findings
Rahim <i>et al.</i> , 2021	A review on smart campus concept and application towards enhancing campus user's learning experience	The paper reveals the usefulness of the concept of smart campus in higher institutions, how various technologies such as Internet of things (IoT) and Information communication (ICT) were integrated to enhance learning, communication and other activities on campus. In doing these, 11 articles from Scopus relating to the objective was reviewed.
Elghonaimy <i>et al.</i> , 2020	Sustainability and GIS in operating smart campuses in the smart cities	The paper focused on the idea of using GIS technology to address the issue of sustainable E-management systems and E-integration which aims at savaging the resources and managing the multidisciplinary activities of the universities in Bahraini. It also reveal the fundamental factors that are to be included in the pre-programming stage; these are users' profiling, users' residential, users' duration, and users' allocation.
Karam <i>et al.</i> , 2020	A strategic framework for smart campus	The paper developed a framework for smart campus to the development of any campus depends on 8 criteria; smart or E-card, smart classroom, energy management, smart transportation, adaptive learning, security & safety, optimization & analytics data center and small facilities. The study propose incorporating

		the above criteria into several sub-applications (25) base on the knowledge of IoT and cloud computing.
Liping H. (2019)	Application of GIS Technology in the Construction of Smart Campus in Colleges and Universities	The paper discussed the knowledge and application practices of GIS technology. Lay emphasis on universities paying more attention to their talent and encouraging them in using GIS technology to solve different problems. The study Concluded that GIS technology has developed rapidly in recent years and has been used in various field to contribute to the growth of the society, but yet to be fully explored in solving problems.
Chan <i>et al.</i> , 2018	Smart library and Smart Campus	The paper discussed the usefulness of library in universities with the creation of digital learning space with the aid of IoT which should not be limited to access to an information only, it concluded that library is tied to the technology development of web 4.0 and the integration of it into smart campus will bring about happy planet index (HPI).
Nachandiya <i>et al.</i> , 2018.	Smart technologies for smart campus information system.	The paper unraveled the significance of smart technologies towards the building of a smart campus, it explained the need to explore the use of Big data, mobile computing, cloud computing and network infrastructure in the development of smart campus. A five-layer architecture was proposed for management and security of a smart campus.
Jiang (2017)	Design and development of smart campus system based on BIM and GIS	The paper discusses construction of smart campus using the networking, database, BIM, visualization and GIS technology. Various systems on which the design and development of smart campus can be built upon were also explained and concluded that though BIM and GIS integration has gained much emphasis in the development of digital city and construction of infrastructures, Yet still at the infancy stage.
Marwa and Elwahab, (2017)	Using geographical information system for campus navigation: case study in Egypt	The paper proposed the usage of GIS techniques to assist new students in navigating the campus environment. The study design and developed tools within the ArcMap environment which could help fresh students to understand their new environment and easily identify their locations. 300 students were used to test run the application, the conclusion shows that 93% accepted the framework while 7% did not.

### 3.0 Discussion of Results and Implications

#### 3.1 Sustainability of GIS Application in Operating Smart Campuses

Elghonaimy *et al.*, (2020) discussed on e-coordination for the Bahrain University and College located at various place but didn't provide a detailed of how this could be achievable in terms of software to be used such as the Arc GIS, QGIS, and IBM etc. The paper did not also articulates or evaluates which of the software's that could be used to handle and process big data and as well performs series of query that will produce with excellent results in replacement of multi-disciplinary situation that will lead to reduce waste. On the other hand, Matlab and Python complex program can as well be written and linked up with the GIS software to enhance quick access and usage of the facilities rather than going by manual or physical method. The study was also restricted to the Bahrain University and Colleges environment only. Meanwhile, the research carried out on the strategic framework for developing a smart campus by Karam *et al.*,(2020) emphasised on IoT and cloud computing as the major supporting infrastructure for operating a smart campus, unlike Nanchandaya *et al.*, (2018) that explained the relevance and use of Big data, mobile computing and network infrastructure in the advancement

of smart campuses. The research work was only limited to IoT and cloud computing towards operating smart campus.

Furthermore, the research on Smart Technology for smart campus information systems by Nachandiya *et al.*, (2018) proposed a five layer concept for the development of smart campus, it gave a detailed explanation of the various layer mentioned with the relevance of their integration but didn't discuss the implementation of the design and how it could be applied by developing a GIS web applications or Android application to manage each of the activities mention in the designed layer. The process of integrating Big data technology, smart device, network, smart application, and cloud computing technology with the help of GIS to produce information services and management for effective campus information systems is of great necessity which the author didn't really discussed. Therefore, there is a need to develop a mobile application for smart campus based on the discussed layer for better understanding and application of smart campus.

Similarly, in a research carried out by Jiang (2017) on the design and development of smart campus system based on BIM and GIS discussed several technology and systems behind the development of smart campus and also described the challenges and difficulties faced in integrating BIM and GIS technology which was still at the infancy stage. This idea can be worked on by making the BIM model as sources of data for the GIS while, the attributes and spatial data to be used in the GIS technology can be integrated into the BIM technology for the purpose of integrating both technology in building up a very effective smart campus in other to avoid duplication and redundancy of data. Also, in a review carried out on smart campus concept and application towards the enhancement of campus users learning experience by Rahim *et al.*, (2021) discussed how smart campus can be operated with more emphasis on the use of augmented reality and virtual reality to enhance campus user's learning experience. Some of the limitations of his works are that the application aspect of his concept of smart campus in university environment was not discussed. And the paper only focused on the learning aspects of smart campuses neglecting other segment that might need greater attention in operating a smart campus which could help the student learning experience.

In a similar work carried out by Chan *et al.*, (2018) on smart library and smart campuses, the study focused on the automation of library and changing with evolution of web 4.0 and it was concerned on how smartness can be incorporated into libraries for both smart campus and library in the city. The limitations of the study centered on developing an idea on how to integrate smart libraries into smart campus in other to bring easiness to student studies. Hence, the need for GIS and a designed prototype to run all the idea in university and colleges for effective functioning. Finally, Marwa and Elwahab (2017) established that using GIS for campus navigation. The paper made use of GIS technology to develop a mobile application which can be used by the students (particularly the fresh student) as guidance in the school environment without going about asking for direction. The idea of the paper was limited to guidance for student in Aboker campus in Egypt only. This can as well be extended to other institutions and it can also be used in other areas such as mobility, management and recording to bring the whole lot of process engaged in conventional school into smartness.

## **3.2 Findings**

### **3.2.1 Based on Technology**

The growth of smart campus requires the usage of a high speed internet services, transfer of information remotely and processing of huge amount of data. Karam *et al.*, (2020) proposed that the framework met for the development of a smart campus should be based on the use of RFID sensor, IoT and cloud computing as the major supporting infrastructure. Karam *et al.*, (2020) and Lovell (2019) also state that the face recognition technology can save up to 2.5 hours per week of teaching time thereby replacing the traditional methods of students' roll call. Daniela, (2020) also explained that the internet of things (IoT) has incorporated some technological tools such as Augmented Reality (AR) and Virtual Reality (VR), laying more emphasis on the use of the AR and VR technology is more attractive than the 2D map view application (Google map) and that they made provision for the education of the disabled. The AR and VR also brightens the chances of disabled students and those that are with impairment issues Rahim *et al.*, (2021). All this improvement in technology can be linked and subsequently be integrated to several GIS software and tools within the institution to operate smart campuses.

### **3.2.2 Based on Environment**

Okusimba (2019) state that the ability of GIS in managing information from environment could be viewed in four perspectives: (i) data collection and management of environmental information i.e (input, update and retrieval); (ii) spatial analysis of environmental information; (iii) modeling; and (iv). Scenarios display and visualization of digital environmental information. There is a limited capacity of the physical environment

where we live and on which our continuing existence depends, (Latu, 2009) which needs to be properly manage and maintain to avoid waste, under-utilized and over-utilized of our resources. It is therefore, important to establish an environmental information system which can easily be achieved with the aid of GIS to maintain our environment. Which includes: Satellite imagery, field/ground surveys, topographic maps, aerial photographs and statistical data from government agencies, cadastral maps and research organizations are just a few of the data sources. (ESRI, 2005) also suggested that building the environmental with the help of GIS software in creating a geo-database for an area of interest. GIS technology is seen as an efficient tool for under-studying the environment, modeling how the environment can respond to natural and man-made factors. And also reporting on environmental phenomena. Divers scientists, regulators, Environmental managers, planners, and many others use GIS to visualize data about natural resources, pollution emissions, ecosystem health, hazard control and climate change (ESRI, 2010).

### 3.2.3 Based on Facilities

In the area of facility management for smart campus, the focus lies on the management of facilities such as buildings, equipment, vehicles etc. Most of these devices have a 3D geometry and many attributes. Graphic Information Systems GIS has capacity to handle such data. (Schürle *et al.*, 1998) GIS can integrate with the top facilities management (FM) software and also help in extending the life span of FM data. GIS is capable of been use throughout the life cycle of a facility, right from deciding where to build, to space planning and several other activities such as; Streamline asset information collection, maintenance, dissemination and use. Facilitate better planning and analysis, and allow efficient distribution of information in and out of the field, providing a wide-ranging view of operations (ESRI, 2010).GIS is of great importance in facility management because with a GIS model of smart campus facilities, we can easily identify problems, possible causes and their likely remedy. The area of technology, campus environment and facilities in schools are three key aspect of any tertiary institution. This three key area of technology are integrated in the development of sustainable framework that could be utilized in the building a sustainable smart campus in tertiary institutions. The framework is provided in the figure 1 below.

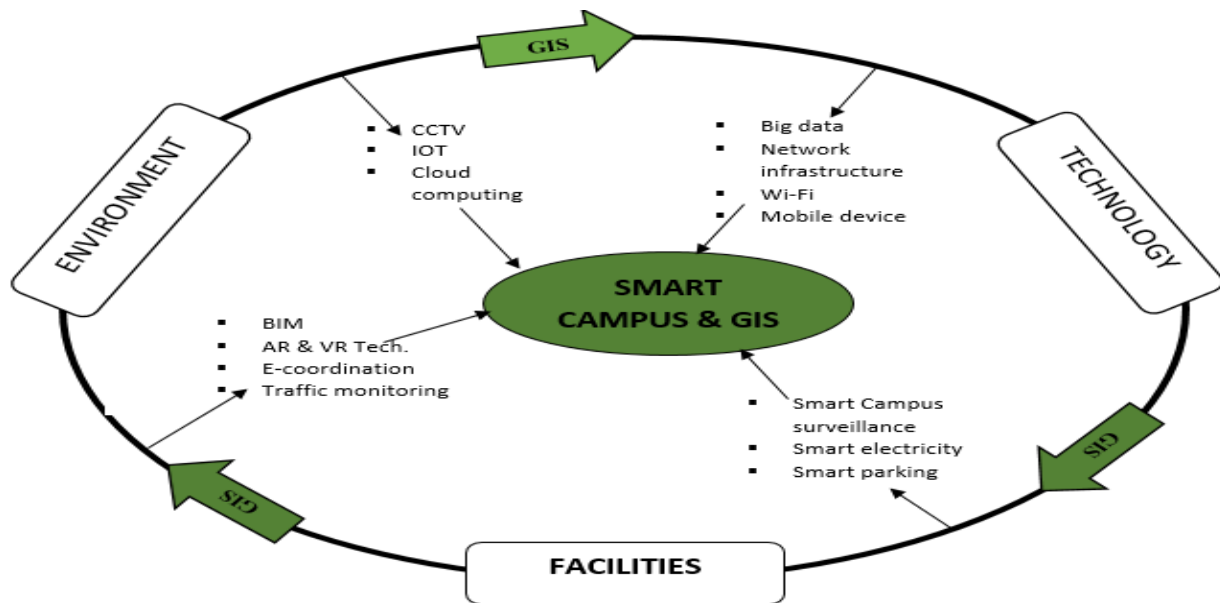


Figure 1: Conceptual Framework

### 4.0 Summary and Findings

The study from the papers reviewed shows that in the development of smart campus for institutions, there is need to integrate a more sophisticated tools and technology requiring sufficient internet services including Big-data, IoT, cloud and mobile computing. Added to this is the design of a GIS web or Android application for all the segments of the institution which should be integrated into a common database for easy access to information. Furthermore, the relevance of GIS in operating a smart campus for sustainable learning environment is a bit complex than to be perceived as mere mapping technology only, rather it should also being seen as to serve and be applicable to other areas. GIS could also be integrated for data analysis and decision-making tool for the smart campus, the operation of GIS in smart campus should have the enhance the efficiency

of services, observes space management, enforces the infrastructure conditions and maintenance, rationalizes the use of energy, evaluate a variety of data graphically, economically etc. (Elghonaimy *et al.*, 2020) GIS technology could be applicable in several other areas, so that people can live more conveniently and have an efficient life style in the campus. With the continuous development of science and technology, the construction of smart campus will go further by making use of other supporting infrastructures such as Big data, mobile computing and network infrastructure rather than relying on IoT and cloud computing alone in the development of smart campus.

## 5.0 Conclusion

The paper concluded that most of the reviewed journals on smart campus focused on the aspect of web or mobile application which is a vital part in smart campus development. Added to this, a more complex and detailed GIS web or mobile computer based program could be designed for each segments from the framework developed that can be integrated together into a common database in other to run a smooth and effective smart campus for institutions.

## 6.0 Recommendations

The following are the recommendations made during this review;

- i. This paper recommends that the GIS tool is still very much underutilized in the development of smart campus
- ii. A complex and detailed GIS web or mobile computer-based program should be designed for each segments of the smart campus.

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