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ORIGINAL

Transforming the Salitre campus into a smart campus: proposal of smart initiatives for the Gerardo Barrios University of El Salvador

Transformando el campus salitre en un smart campus: propuesta de iniciativas inteligentes para la Universidad Gerardo Barrios de El Salvador

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ABSTRACT

This study proposes a set of initiatives to transform the Salitre campus of the Gerardo Barrios University in San Miguel, El Salvador, into a *Smart Campus* inspired by Smart City concepts. Through a documentary research, a detailed diagnosis of the campus and a SWOT analysis, several proposals were defined grouped in six axes: Smart Government, Smart Environment, Smart Living, Smart Economy, Smart People and Smart Mobility. The viability of the initiatives was evaluated considering their acceptance by the authorities and stakeholders, as well as a feasibility study. The results show that the transformation of the Salitre campus into a *Smart Campus* may be possible and would bring multiple benefits in terms of efficiency, sustainability, innovation and quality of life for the university community. The study establishes the basis for future projects and research, promoting digital and sustainable transformation in the educational and community environment of El Salvador.

Keywords: Smart City; Technology; Innovation; University Community; Sustainability.

RESUMEN

El presente estudio propone un conjunto de iniciativas para transformar el campus Salitre de la Universidad Gerardo Barrios en San Miguel, El Salvador, en un *Smart Campus* inspirado en los conceptos de Smart City. Mediante una investigación documental, un diagnóstico detallado del campus y un análisis FODA, se definieron diversas propuestas agrupadas en seis ejes: Smart Government, Smart Environment, Smart Living, Smart Economy, Smart People y Smart Mobility. La viabilidad de las iniciativas se evaluó considerando su aceptación por parte de las autoridades y grupos de interés, así como un estudio de factibilidad. Los resultados demuestran que la transformación del campus Salitre en un *Smart Campus* puede ser posible y aportaría múltiples beneficios en términos de eficiencia, sostenibilidad, innovación y calidad de vida para la comunidad universitaria. El estudio establece las bases para futuros proyectos e investigaciones, impulsando la transformación digital y sostenible en el ámbito educativo y comunitario de El Salvador.

Palabras clave: Smart City; Tecnología; Innovación; Comunidad Universitaria; Sostenibilidad.

INTRODUCTION

The concept of smart cities began in the 1960s and 1970s when the U.S. Bureau of Community Analysis began using databases, aerial photographs, and cluster analysis to collect data, direct resources, and issue reports to target services, mitigate disasters, and reduce poverty (TWI-GLOBAL, 2019). This marked the creation of the first generation of smart cities. According to the IDB (2016), a smart city places people at the

center of development, integrating information and communication technologies into the city's communication technologies in city management. A smart city uses new technologies to respond to the constantly changing needs of the administration, businesses, and citizens (Cabello, 2022). This translates into better quality public services, greater transparency, and more efficient, accessible, and inclusive management for the population (Romero Tarín, 2018). They have the potential to efficiently manage energy resources without neglecting economic, social, and cultural development. To be profitable, cities must attract talent, development, culture, knowledge, and innovation. Smart City applications improve the quality of life and the efficient management of resources.

Smart Campus experiences are a fact of what is done in smart cities applied to the university environment. Many campuses are small cities, interconnected organisms where students and faculty can find everything they need (Martinez, 2017). University campuses can be conceived as complex systems composed of various elements, such as users, buildings, infrastructures, and others, which are constantly influenced by each other (Mattoni et al., 2016). A Smart campus is a university campus that uses advanced technology to improve efficiency, safety, and quality of life for its students, faculty, and administrative staff (Villegas Chiliquinga, 2020). Smart campuses use Internet of Things (IoT) technology, artificial intelligence (AI), Big data, and cloud computing to improve resource management and offer personalized services to the university community. A smart university campus offers numerous benefits similar to a smart city's (Pérez Rodríguez, 2022). Technology improves energy efficiency, mobility, safety, security, and quality of life. This involves reducing energy consumption, optimizing transportation, increasing security with surveillance cameras and access control, and fostering innovation and collaboration through sustainable technologies and a smart environment (Rodriguez Rodriguez et al., 2023). However, existing initiatives focus on the specific needs of each university without a generic model applicable to all campuses (Min-Allah & Alrashed, 2020). The evolution of Smart Cities has inspired the Smart Campus concept, which seeks to apply advanced technologies and sustainable practices in university environments. This research proposes and validates initiatives to transform the Salitre campus of Gerardo Barrios University in El Salvador into a Smart Campus. The objective is to identify key elements of a smart campus, perform a diagnosis of the campus, and define viable proposals. It is expected that the results will serve as a basis for future projects and research, promoting digital and sustainable transformation in the educational and community environment of the country.

METHOD

The research is of the documentary type (Tancara, 1993), which consists of the search, selection, reading, analysis, interpretation, and synthesis of information contained in documents to create new knowledge from the review of multiple bibliographic sources (Sánchez et al., 2020). To understand the concept of a Smart Campus, a literature review on Smart Cities and Smart Campus was conducted, consulting various materials such as scientific articles, reports, and case studies to identify the characteristics and components of a Smart Campus, as well as the concepts, practices, challenges, and benefits associated with the transformation of a traditional campus into a smart and connected environment.

After acquiring theoretical knowledge through documentary research, a propositional approach was adopted to generate specific proposals and solutions in the project context. According to Hernández Sampieri et al. (2010), propositional research focuses on identifying and proposing solutions or improvements to achieve desired results and overcome problems or deficiencies in a particular system, process, or situation. This approach involved diagnosing the Salitre Campus and identifying its strengths, weaknesses, opportunities, and threats concerning the implementation of Smart Campus initiatives.

To obtain the diagnosis and SWOT analysis, three data collection techniques were used: interview, observation, and survey.

- To collect the necessary data for the diagnosis and SWOT analysis, a structured interview was conducted with the person in charge of the campus, using a previously prepared interview guide.
- An observation of the physical characteristics of the campus was carried out using a checklist to record relevant elements such as infrastructure, spaces, equipment, and technological resources.
- Finally, a survey to assess the campus as a Smart Campus was applied to a sample of 6 people, composed of administrators, researchers, and personnel directly involved, using a questionnaire with closed questions and rating scales to evaluate the degree to which technology can be used and the potential for transformation towards a Smart Campus.

The sample was selected considering inclusion criteria such as being part of the administrative or research staff, being directly involved in the operation of the campus, and having a broad knowledge of the characteristics and operation of the institution. The sample size was 6 participants who met the criteria above.

Based on the analysis of the Salitre Campus, the definition of the SWOT, and taking as a reference success cases of other institutions, a series of initiatives oriented towards adopting Smart Campus at the Salitre Campus

were defined. The success cases of the institutions served as inspiration and guide to formulate proposals adapted to the specific context of the Salitre Campus. These institutions' strategies, technologies, and approaches were analyzed, and their applicability and potential impact on the Salitre Campus were evaluated.

The initiatives were oriented toward adopting the principles and technologies of a Smart Campus, seeking to improve efficiency, sustainability, innovation, and quality of life in the environment. To evaluate the acceptability of the proposed initiatives, an evaluation process was designed to focus on the opinions and interests of those directly involved with the campus. The evaluators comprised researchers and coordinators who play key roles on the campus. After evaluating the acceptability of the proposed initiatives by the key stakeholders of the Salitre Campus, the next step in the project methodology was to determine their feasibility of implementation. Three fundamental areas were analyzed: physical resources, financial resources, and feasibility of implementation. It was established that an initiative is considered viable for the campus if its feasibility in these three aspects is acceptable.

RESULTS

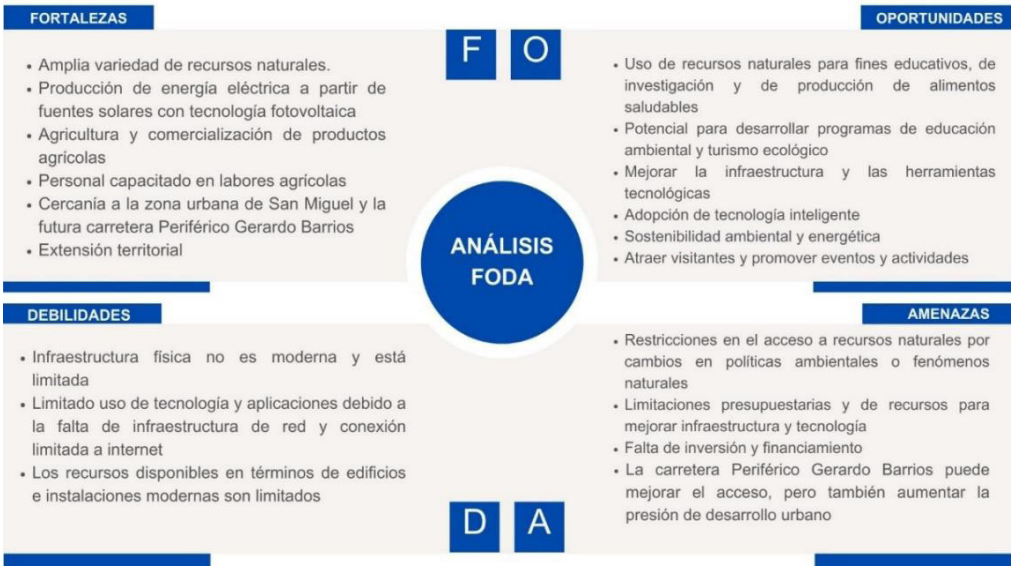

Figure 1. Diagnosis of the Salitre Campus

The figure shows the analysis of the strengths, opportunities, weaknesses and threats of the Salitre campus.

The SWOT analysis of the Salitre campus provides insight into its current situation and potential to become a Smart Campus. The Salitre campus possesses a solid base of natural resources and agricultural capabilities that can be leveraged to drive sustainable initiatives and generate benefits for the university and the local community. Biodiversity, water resources, and solar energy production are valuable assets that must be protected and used strategically (Faghihi et al., 2015; Sureda et al., 2017). However, it is also clear that the physical and technological infrastructure of the campus is a significant constraint that needs to be addressed to move toward a Smart Campus model. Modernizing buildings, upgrading facilities, and investing in smart technologies will improve campus quality of life, operational efficiency, and educational experience (Ramos et al., 2023).

The SWOT analysis highlights the importance of taking advantage of the research, environmental education, and ecotourism opportunities offered by the Salitre campus. The creation of specialized academic programs, promotion of research activities, and collaboration with strategic partners can help position the campus as a leader in sustainability and environmental knowledge (Mazó-Quevedo et al., 2022).

The opinion on using innovative technologies on the Salitre campus reflects positively, as all responses were positive, indicating strong support for adopting innovative technologies. This degree of acceptance may be due to factors such as recognition of the potential benefits that these technologies can bring to the campus environment.

25 % of respondents consider that improving efficiency in managing campus resources is a key aspect of how a Smart Campus could benefit users. Seventy-five percent believe that both improved efficiency in managing campus resources, security, and access to information and services improves the user experience on campus. Although the options of campus security and ease of access to information and services do not individually stand out, the "All of the above" options suggest that the majority of respondents recognize that a Smart Campus can have a positive impact on multiple aspects of the user experience, indicating a widespread appreciation

for technological improvements on campus.

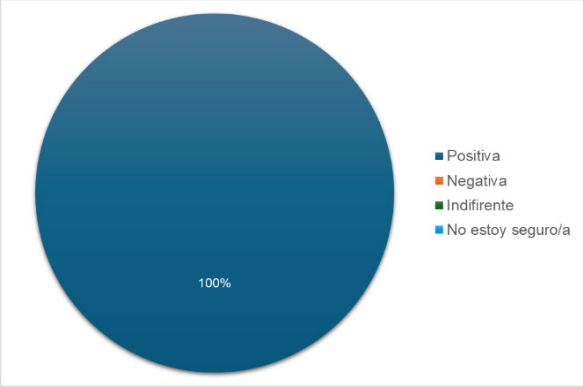

Figure 2. Valuation of the Salitre Campus as a Smart Campus

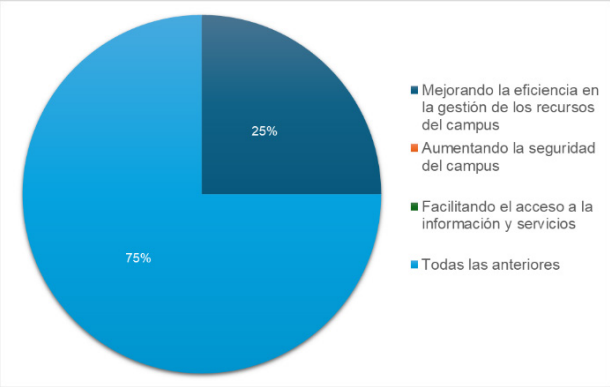

Figure 3. User experience at campus salitre

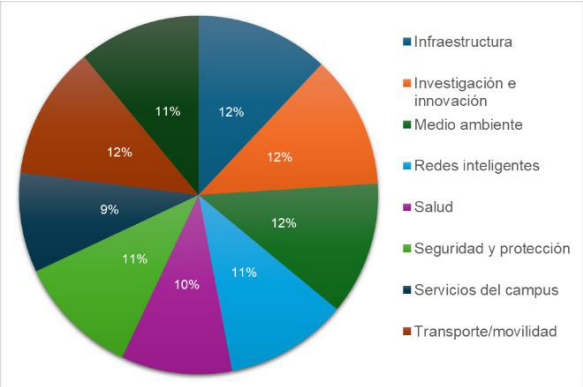

Figure 4. Valuation of areas and technologies of campus salitre

The responses obtained on assessing the importance of various areas and technologies in a Smart Campus indicate a relatively even distribution regarding the perceived importance of these areas and technologies in a Smart Campus.

Relatively evenly distributed in terms of the perceived importance of these areas. Infrastructure is considered important, receiving a score of 12 %, reflecting the understanding that a solid foundation is essential for any Smart Campus initiative. Research and innovation are also rated at 12 %, indicating a recognition of the need to foster research and development in an academic environment. The importance given to the environment with 12 % indicates that sustainability and environmental management are relevant issues for the campus community. Transportation and mobility are rated at 12 %, indicating the importance of facilitating accessibility and mobility within the campus. Smart grids, which include gates and parking systems, are also considered important at 11 %, which could indicate a concern for improving efficiency and safety on campus. The importance given to renewable energy at 11 % reflects an interest in energy sustainability and reducing the campus's carbon footprint. Health, which encompasses areas such as relaxation and healthy eating, receives 10 %, reflecting an appreciation for the well-being of campus users. Safety and security are also rated at 11 %, indicating the importance of ensuring the campus community's safety. Moreover, campus services score 9 %,

suggesting that, while important, they may be considered a lower priority than other areas.

Figure 5. Benefit assessment for different groups of users of the Salitre campus.

The responses obtained reflect a generally positive perception of the benefits of implementing a Smart Campus project at the Salitre campus. First, the rating given to both research teaching staff and partners/ suppliers, with 18 %, indicates that these groups are expected to derive significant benefits from implementing smart technologies. For research faculty, this could translate into better research resources and a more efficient environment for their work. On the other hand, partners/suppliers may benefit from a smoother relationship with the institution and process optimization. The 17 % rating given to visitors indicates that the importance of improving their experience on campus is recognized, which could attract more visitors and promote events and activities on campus. The fact that students, administration, and services staff receive the same rating level, both at 16 %, suggests an understanding that technology can improve quality of life and efficiency in resource management for both students and support staff. Finally, the 15 % given to other staff reflects a recognition that all campus community members can benefit to some extent from a smarter, more technologically advanced environment.

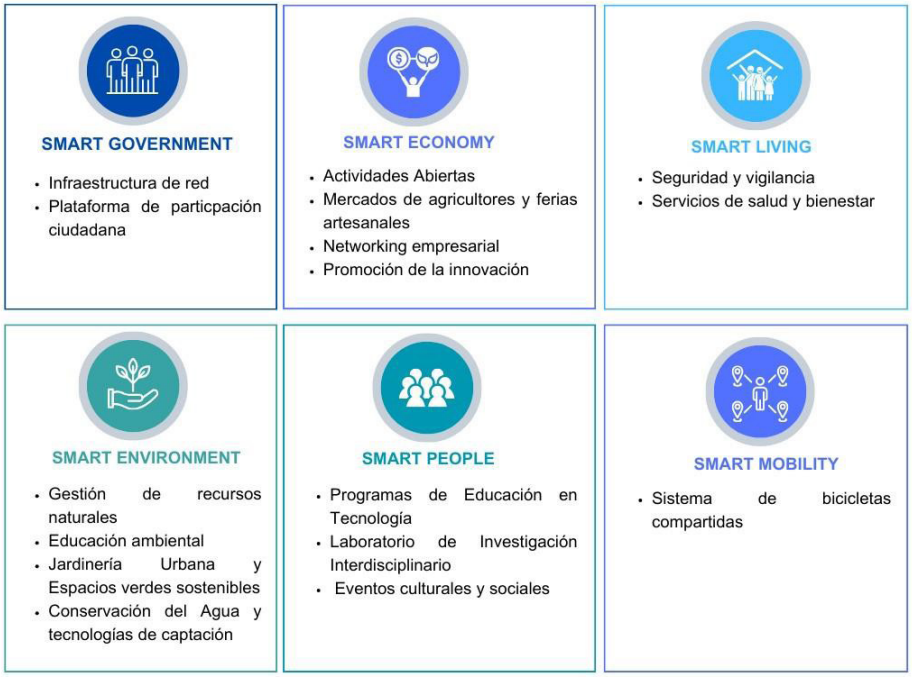

Figure 6. Acceptable initiatives for campus salitre

From the above analysis, it can be noted that:

- There is strong support for adopting innovative technologies at the Salitre campus, indicating a positive community perception towards advanced technology in the campus environment.
- Implementing a Smart Campus is an opportunity to improve the user experience in several aspects, including efficiency in resource management, security, and access to information and services.
- The importance of various areas and technologies in a Smart Campus is valued, such as infrastructure, research and innovation, environmental sustainability, efficient mobility, security, renewable energies,

health and services, and health and campus services. However, some of them receive a slightly higher score.

- It is recognized that all groups of the campus community, from students to visitors to partners/suppliers, have the potential to experience improvements in their quality of life and development through the implementation of smart technology on campus.

The figure shows the ranking of acceptable initiatives for the Salitre campus, evaluated according to the criteria: physical resources, financial resources and possibility of execution.

The figure above presents a set of acceptable initiatives grouped into six main categories to transform campus Salitre into a Smart Campus. Each category includes specific initiatives to improve the campus experience and operation. A network infrastructure and a citizen participation platform are proposed in the Smart Government category. Smart Economy focuses on open events and activities, farmer's markets and craft fairs, business networking events, craft fairs, business networking events, and the promotion of innovation. The Smart Environment category addresses sustainable natural resource management, environmental education, urban gardening, sustainable green spaces, and water conservation and harvesting technologies. Smart People includes technology education programs, interdisciplinary research labs, and cultural and social events. Smart Living highlights security, surveillance, and health and wellness services. Finally, Smart Mobility suggests a bike-sharing system to encourage sustainable mobility. These initiatives seek to transform the campus into a smarter, more sustainable, and enriching environment, taking advantage of technology, encouraging community participation, and promoting innovative practices in various areas. The implementation of these initiatives will lay the groundwork for creating a Smart Campus that improves the quality of life, efficiency, and experience of visitors, students, faculty, researchers, and staff.

DISCUSSION

The results obtained in this study show that the transformation of the Salitre campus of Gerardo Barrios University into a Smart Campus is a proposal with a high level of acceptance by the main stakeholders. The acceptability assessment conducted with key campus stakeholders revealed strong support for adopting innovative technologies and a positive perception of the potential benefits of a Smart Campus. This coincides with what has been pointed out by various authors, who highlight that a Smart Campus uses advanced technology to improve efficiency, safety, and quality of life of the university community, offering similar benefits to those of a smart city (Pérez Rodríguez, 2022; Rodríguez et al. et al., 2023; Villegas Chiliquinga, 2020).

However, it is important to consider that existing Smart Campus initiatives focus on the specific needs of each university (Min-Allah & Alrashed, 2020), so it is essential to adapt the proposals to the particular characteristics and requirements of the Salitre campus. In addition, given that university campuses are complex systems (Mattoni et al., 2016), adopting a collaborative approach to implement the initiatives is essential.

The transformation of the Salitre campus into a Smart Campus would contribute to the achievement of the Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda since, according to (Rodríguez Cubreros, 2019), Smart Universities offer a framework that favors collaboration, synergy and cooperation in different areas of activity in the countries of the region, thus demonstrating the commitment of the Gerardo Barrios University to social responsibility and sustainable development.

CONCLUSIONS

The study presents a notion that the transformation of the Salitre campus of Gerardo Barrios University into a Smart Campus could be carried out as it has a high level of acceptance by the main stakeholders. The proposed initiatives, grouped into six categories (Smart Government, Smart Economy, Smart Environment, Smart People, Smart Living, and Smart Mobility), cover several key aspects for transforming the campus into a smart, sustainable, and enriching environment. The acceptability assessment conducted with key campus stakeholders revealed strong support for adopting innovative technologies and a positive perception of the potential benefits of a Smart Campus for students, faculty, researchers, administrative staff, visitors, partners/suppliers, and the wider community.

The acceptability of the initiatives confirmed that the proposed initiatives could be implemented on campus, which would bring multiple benefits, such as improving efficiency in resource management, fostering research and innovation, promoting environmental sustainability, optimizing mobility, strengthening safety and well-being, and creating a more participatory and collaborative environment for all campus users and the wider community.

To make this process of transformation of the Salitre campus possible, a detailed implementation plan is required that establishes priorities, deadlines, responsibilities and monitoring and evaluation mechanisms, ensuring the allocation of the necessary resources and seeking the support of the university administration, the local community and external financing.

To measure the impact and effectiveness of the initiatives, it is essential to implement a continuous monitoring and evaluation system to identify areas for improvement and make necessary adjustments, considering indicators of campus performance and the well-being and development of the surrounding community. Sharing the results and lessons learned from the project with other institutions, organizations, communities and society in general will contribute to the advancement of knowledge and the promotion of Smart Campuses as models of innovation, sustainability and social transformation in El Salvador and the region.

The successful transformation of the Salitre Campus into a Smart Campus would not only generate significant benefits for the university community and its environment, but would also position the Gerardo Barrios University as a leader in innovation, sustainability and social responsibility in El Salvador and the Central American region. The Salitre Campus has the potential to become a reference model for other educational institutions and communities seeking to implement smart and sustainable initiatives, adapted to their own contexts and needs.

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Writing – original draft: Gisela Yasmín García Espinoza.
Writing – review and proof editing: Gisela Yasmín García Espinoza.