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SUSTAINABLE LIBRARIES: HARNESSING SMART LIBRARY FOR A GREEN FUTURE

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Abstract:

In pursuing a sustainable future, libraries have emerged as crucial advocates for environmental, financial and social awareness. This paper explores the theoretical review of integrating of smart library elements (smart technology, smart services and smart people) in libraries to promote sustainability. By exploring the seamless convergence of these elements, the paper unveils a new paradigm in which libraries are moving beyond their traditional roles to become dynamic, environmentally conscious places. Smart technologies provide energy efficiency, resource optimisation and digitisation, while smart services optimise the user experience and promote sustainability awareness. Smart people that include librarians and staff empowered users serve as crucial agents of change. Despite the challenges posed by technological barriers and costs, the vision for libraries is clear: to lead through continuous adaptation, innovation and collaboration. The ultimate goal is to create sustainable smart libraries that herald a greener and more responsible future.

Keywords:

Sustainable Library, Smart Library, Green Library

Introduction

At a time when environmental protection and sustainable practices are becoming increasingly urgent, libraries have emerged as important advocates for promoting environmental, financial and social awareness. Elements in smart library are expected to have an impact in supporting sustainable library. Exploring the seamless convergence of these elements it presents a new paradigm in which libraries are moving beyond their traditional roles to become dynamic and

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environmentally aware spaces (Baryshev, 2021; Isaac & Omame, 2020). Smart technologies enable energy efficiency, resource optimisation and digitisation, while smart services enhance the user experience and promote sustainability awareness (Duncan, 2021). Librarians and empowered users are key change agents steering the library ecosystem towards a sustainable future. Despite the challenges posed by technological barriers and costs, the vision for libraries remains clear: to lead through continuous adaptation, innovation and collaboration. The ultimate goal is to create sustainable, smart libraries that herald a greener and more responsible future.

The IFLA (International Federation of Library Associations and Institutions) defines a sustainable library as one that "operates responsibly in environmental, economic and social terms to meet the needs of the present without compromising the ability of future generations to meet their own needs" (International Federation of Library Associations, 2022). This definition emphasises the importance of sustainable practices for library operations and services, including resource consumption, waste reduction, energy efficiency and promoting sustainable development through education and awareness-raising. A sustainable library aims to minimise its impact on the environment, reduce its carbon footprint and promote sustainability in its community while ensuring its long-term viability and financial sustainability.

The green library is another term to consider when defining a sustainable library (Aulisio, 2013; Ismail et al., 2022; Jankowska et al., 2014). Most scholars agree that both terms encompass the exact definition. Ismail et al. (2022) stated that both 'green library' and 'sustainable library' refer to modernised libraries that minimise energy consumption while maximising the use of renewable energy sources. It is concluded that both terms refer to a library that has been developed to be environmentally friendly and environmentally conscious.

However, the study by Fedorowicz-Kruszewska (2019) provides a clearer description and distinguishes between a "green library" and a "sustainable library." A green library is designed to minimise negative impacts on the natural environment and maximise indoor environmental quality. This is done through careful site selection, using natural building materials and biodegradable products, conserving resources (water, energy, paper) and responsible waste management (recycling, etc.). A sustainable library is a library that takes all aspects into account: Environmental (infrastructure, maintenance), Economic (funding, budget, potential human development, impact of local economic conditions) and Social (access to knowledge and technology, sufficient salaries for staff, healthy working and study conditions).

A smart library is a technologically advanced library that provides specialised services via electronic and communication technology (Gul & Bano, 2019). It comprises cutting-edge technologies, including cloud computing, data mining, artificial intelligence, and location-based technology (Cao et al., 2018; Fang, 2020; Schöpfel, 2018). Cao et al., (2018) stated that a smart library focuses on three primary elements: Technology, Service, and People. It seeks to increase information literacy and offer interactive, innovative, and international services (Baryshev et al., 2018).

A smart library is characterised not only by its technological capabilities, but also by its holistic approach to integrating services and engaging users (Adetayo et al., 2021; Schöpfel, 2018). Smart libraries aim to create seamless user experiences by using automation, personalisation

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and innovative services. Librarians in smart libraries are expected to have additional skills such as data literacy, social intelligence and design thinking to help them adapt to the evolving information and technology landscape. Overall, a smart library differs from other types of libraries in its integration of advanced technologies, focus on user-centred services and the skills required of librarians (Cao et al., 2018; Jadhav & Shenoy, 2020). By harnessing the power of IoT (Internet of Things), AI (artificial intelligence) and virtual reality, smart libraries are able to provide efficient information services, improve the user experience and adapt to the changing needs of the digital age. This article explores the transformative potential of integrating smart technology, smart services and smart people within the context of libraries to advance sustainability creating a new kind of "smart sustainable library" for a greener future.

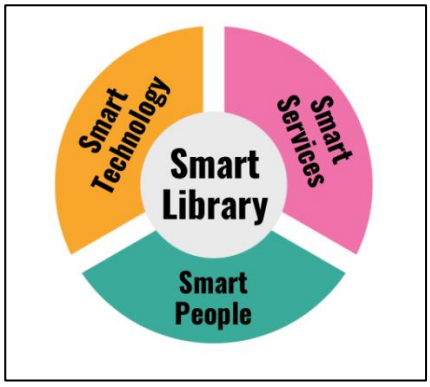

Figure 1: Smart Library Elements

Figure 2: Sustainable Library Components

Methodology

The methodology employed in this study comprises a library search and an assessment of prior literature reviews pertaining to sustainable libraries and smart libraries. The library conducts a comprehensive investigation of online resources. The references are provided by online databases, including Web of Science, Scopus, and Google Scholar. The search is restricted to smart libraries, green libraries, sustainable libraries, smart technologies, smart services, and smart people. References are exclusively extracted from journal articles. Hence, the constraints of this study may stem from the limited number of resources available in databases, given that conference papers and book chapters are also excluded from the search results. The procedure for identifying resources in smart and sustainable libraries is illustrated in Figure 3.

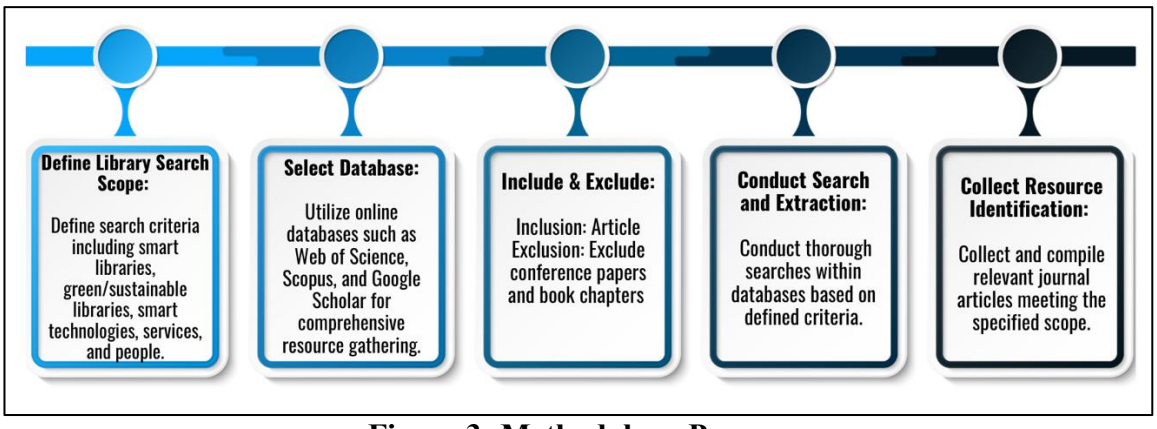

Figure 3: Methodology Process

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Theoretical Framework

A comprehensive theoretical framework is presented in Figure 3, which integrates significant contributions from Jacobs (2022), Cao et al. (2018), Jerkov et al. (2015), Koukopoulos et al. (2019), and Mohammed et al. (2019). This diagram functions as a theoretical guide, consolidating the interaction among smart library elements, which are technology, services, and people, in the context of sustainable libraries.

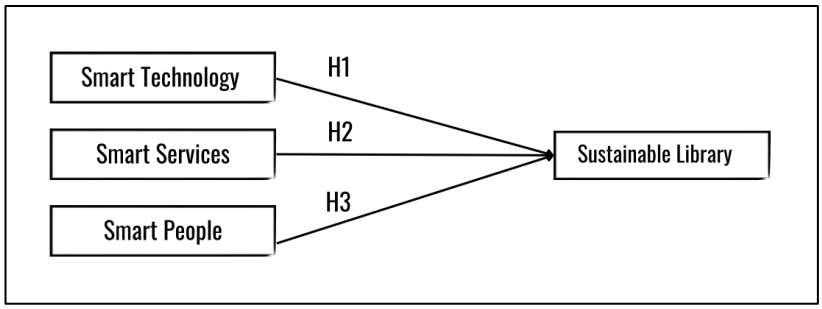

Figure 4: Theoretical Framework And Hypothesis Development

Based on the findings from various sources, the hypothesis that there is a relationship between smart libraries and sustainable libraries, suggesting that the more sustainable libraries utilize smart library elements, the better the future for green achievements, is supported.

H1 - Smart Technology is Positively Related to Sustainability

Smart libraries that integrate advanced technologies into their operations are at the forefront of sustainability efforts. The adoption of energy-efficient systems such as LED (light-emitting diode lighting) and HVAC (heating, ventilation and air conditioning) systems is critical. LED Lighting uses much less energy than traditional lighting systems, which reduces electricity consumption and associated carbon emissions (Mohammed et al., 2019). On the other hand, automated HVAC systems optimise temperature control and ventilation based on real-time occupancy data, preventing wasted energy in unoccupied spaces. By implementing these measures, smart libraries reduce their environmental impact by lowering energy consumption and greenhouse gas emissions.

Smart libraries often integrate renewable energy sources, such as solar panels, into their infrastructure to demonstrate their commitment to sustainability (Jerkov et al., 2015). Solar panels convert solar energy into electricity, which can then be used to power library facilities. This switch to renewable energy not only reduces the library's dependence on fossil fuels, but also contributes to a cleaner energy mix in line with overall environmental goals.

In addition to these energy-saving measures, smart libraries use intelligent sensors and monitoring systems to continuously monitor and optimise energy consumption (Jerkov et al., 2015). These sensors can detect occupancy levels, temperature fluctuations and lighting conditions. Using this data, libraries can make real-time adjustments to heating, cooling and lighting to ensure that all available resources are used efficiently. In this way, they reduce waste and operating costs and become more economically sustainable.

In summary, smart libraries take a multi-layered approach to sustainability. They use energy-saving technologies, renewable energy sources such as solar energy and smart sensors to

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monitor and optimise resource consumption. This comprehensive strategy reduces their environmental footprint and promotes economic sustainability by reducing operating costs. Smart libraries demonstrate the potential of advanced technologies and environmentally conscious practises to create more sustainable and efficient library services by leading by example.

H2 - Smart Services is Positively Related to Sustainability

Smart libraries use their digital capabilities to provide services that enhance the user experience and contribute to environmental sustainability in several ways. First, they offer extensive digital resources such as e-books, e-journals and online databases, reducing the demand for traditional print (Koukopoulos et al., 2019). This can save paper and reduce transport emissions associated with producing and distributing physical books.

In addition, smart libraries are expanding their commitment to sustainability by offering services that actively promote environmentally conscious practices in their communities. Bike-share programmes, for example, encourage patrons to choose sustainable modes of transportation, reducing dependence on fossil fuels and carbon emissions (Jerkov et al., 2015). Individuals can grow their food in community gardens, reducing the environmental impact of transporting food long distances and encouraging greater community engagement.

In addition, smart libraries take care of their operations and implement sustainable practices inside. They build and furnish with recycled materials, reducing the need for fresh resources. They can reduce their environmental footprint by implementing waste reduction strategies such as efficient recycling programmes and waste minimisation initiatives (Duncan & Sterling, 2023). Smart libraries also reduce energy consumption, implement environmentally friendly building designs and optimise resource allocation, all contributing to economic and environmental sustainability.

In summary, smart libraries are dynamic centres that go beyond traditional functions. They provide digital resources to reduce paper use, offer services that actively support sustainable practices in their communities, and apply sustainable business strategies. By incorporating these elements, smart libraries exemplify a holistic approach to sustainability that considers environmental, economic and social factors and serves as a model for environmentally responsible and community-oriented institutions.

H3 - Smart People is Positively Related to Sustainability

Smart people in smart libraries play a critical role in promoting sustainability through several interrelated strategies. First, they serve as knowledge hubs by providing access to various information and resources related to sustainable practices (Mohammed et al., 2019). Library patrons can access books, magazines and online databases that contain information on recycling methods, composting techniques, energy-saving tips and other environmentally friendly practices. By providing easy access to this information, libraries empower people to adopt sustainable behaviours in their daily lives.

In addition to disseminating information, smart people are also actively engaged in sustainability in their communities. They offer educational programmes and seminars on various topics related to sustainability. These programmes may include seminars on reducing

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carbon footprints, lectures on mitigating climate change, and hands-on activities on environmentally friendly gardening and composting (Jerkov et al., 2015). By organising and facilitating these events, libraries promote a culture of environmental responsibility by allowing people to learn, discuss and implement sustainable practices.

A part of that, smart people recognise the importance of collaboration. They form alliances with local organisations, environmental groups and businesses to advance community sustainability initiatives (Koukopoulos et al., 2019). These alliances can lead to joint projects such as community clean-ups, tree-planting initiatives and recycling drives. By working with different stakeholders, libraries use their position as community hubs to mobilise resources and expertise to have a more significant and lasting impact on sustainability.

Integration of Smart Library Elements for a Green Future

Integrating smart library elements, including smart technology, smart services and smart people, for a green future represents a transformative approach combining advanced technologies and sustainable practices to create environmentally conscious and efficient library spaces. Smart libraries, characterised by the fusion of smart technologies, smart users and smart services, are at the forefront of this integration (Gul & Bano, 2019). These libraries use innovative technologies such as the Internet of Things (IoT), artificial intelligence and big data to optimise resource use, reduce energy consumption and minimise environmental impact, which aligns with sustainability principles (Cao et al., 2018). In addition, the concept of green libraries, which focuses on sustainable building design, green management and environmental strategies, plays a central role in integrating smart library elements for a green future. Green libraries promote sustainability through education, operations and outreach, contributing to the overall environmental goals of smart libraries (Fedorowicz-Kruszewska, 2022). In addition, the sustainable design of library spaces characterised by open, collaborative and welcoming learning environments supports sustainable learning for the future. It is in line with green building and sustainability principles. In addition, the involvement of smart people, including information professionals and users, is crucial to ensure the effective use of technological tools and participation in smart library activities (Jacobs, 2022). Developing smart services, such as e-learning technologies and innovative sustainable skills development for library staff, further contributes to integrating elements of smart libraries for a green future (Shahzad & Khan, 2022). To summarise, integrating smart library elements for a green future is a holistic approach combining advanced technologies, sustainable building design, environmental strategies and social initiatives to create environmentally conscious and efficient library spaces.

Future Research

In the evolving landscape of smart libraries and sustainability, fascinating research opportunities await exploration. Future studies could look at user behaviour and preferences in smart libraries and decipher the driving forces behind sustainable practices and technology adoption. Understanding the psychological and sociological aspects of user engagement with sustainability can lead to targeted sustainability initiatives and optimise their effectiveness.

Looking ahead, incorporating ethical considerations into library sustainability is paramount. An important focus is on the ethical implications of data collection and use in smart libraries. Research can provide a robust ethical framework for handling user data that ensures privacy, consent and transparency in data-driven sustainability initiatives. Eliminating bias in data collection and promoting fairness, especially in community-driven sustainability programmes,

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are essential. In addition, assessing the environmental and social impacts of library technology production, use, and disposal is critical. Ethical perspectives should also extend to ensuring equal access to smart technologies and services for all community members, promoting inclusion and equal opportunities. This collective integration of ethics into research and sustainability efforts will drive balanced development and move us towards a future that balances technological advancement with ethical integrity and societal well-being.

Conclusion

This paper has successfully developed a theoretical framework that is useful for future research in this area. The development of libraries into smart, sustainable ecosystems is an important step towards a green future. By integrating smart technologies, services and people, libraries take a holistic approach to sustainability. Energy-efficient systems powered by smart technology minimise resource consumption and reduce the carbon footprint. At the same time, the inclusion of renewable energy sources underlines the commitment to a cleaner, greener energy mix.

Smart services offered by smart libraries, such as access to digital resources and sustainability-focused programmes, encourage environmentally conscious practices among library patrons. As custodians of knowledge, librarians play a central role in promoting sustainability and engaging the community in green initiatives. Collaboration with local organisations amplifies the impact and promotes a culture of sustainability beyond the library walls.

Real-time data and smart monitoring systems enable libraries to make data-driven decisions to optimise resource allocation and energy consumption. This data-centric approach minimises waste and promotes economic sustainability by reducing operating costs. The integrated efforts of technology, services and people engagement in smart libraries underscore the potential of libraries to lead by example, champion sustainability, and advocate for a better, greener future. Smart libraries serve as catalysts for environmental stewardship, demonstrating how comprehensive integration of smart elements can drive sustainable, environmentally conscious change to enhance the smartness and sustainability of libraries.

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