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SUSTAINABLE LIBRARIES FOR A SUSTAINABLE FUTURE: GREEN AND DIGITAL INNOVATIONS ALIGNED WITH THE SUSTAINABLE DEVELOPMENT GOALS

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Abstract

In response to the global imperative for sustainability and digital innovation, libraries are increasingly transforming their infrastructure, services, and operations to align with environmental and technological goals. This paper reviews sustainable practices in public and academic libraries, focusing on the convergence of green infrastructure and digital transformation, with particular emphasis on the Indian context. Drawing on national and international examples, such as the Anna Centenary Library in Chennai, Perma Karpo Library in Ladakh, and the SDG-aligned design of the Rajagiri Business School Library, the study illustrates how libraries function as both physical learning spaces and proactive agents of climate consciousness and digital inclusion. It examines eco-friendly building standards like IGBC (Indian Green Building Council) and GRIHA (Green Rating for Integrated Habitat Assessment), energy-efficient systems, digitization initiatives, and the role of libraries in advancing the United Nations Sustainable Development Goals (SDGs). Despite notable progress, challenges remain, including funding limitations, digital disparities, and institutional resistance to change. The paper concludes by recommending strategies to embed sustainability into library planning, policy, and practice, ultimately positioning libraries as essential drivers of sustainable, knowledge-based societies.

Keywords: Digital transformation, Eco-librarianship, Green library practices, Sustainable Development Goals, Sustainable libraries.

1. INTRODUCTION

The global emphasis on sustainability, reflected in the United Nations' Sustainable Development Goals (SDGs), has significantly influenced various sectors, including education and information services. Libraries, long viewed as centres of learning and community engagement, are increasingly being recognised for their potential to model and promote sustainability through environmentally sound infrastructure and digital innovations. As institutions that serve diverse populations across educational, cultural, and socioeconomic backgrounds, libraries are uniquely positioned to foster sustainable behaviors and contribute to climate action, digital inclusion, and responsible resource use (Graham-Clare, 2022; Robertsone & Lapiņa, 2023).

Sustainable library practices encompass two major transformations: green practices and digital strategies. Green libraries integrate principles of environmental responsibility by using sustainable building materials, promoting energy and water efficiency, encouraging recycling, and supporting environmental education (Patil & Jani, 2024; Vasanthi, 2019). Green libraries are purposefully designed to reduce ecological footprints and foster environmentally responsible behaviors within their spaces and services. According to Panda et al. (2025), green libraries serve as transformative institutions that support several SDGs through the integration of eco-friendly infrastructure, energy-

efficient technologies, digital resources, and community engagement. According to Biswas (2019), these libraries prioritise environmental sustainability through strategic site selection, use of eco-friendly and biodegradable materials, resource conservation (including water, energy, and paper), and responsible waste management such as recycling.

The green library movement in India has gained traction through institutional initiatives aligned with rating systems like GRIHA (Green Rating for Integrated Habitat Assessment) and IGBC (Indian Green Building Council), as well as global certifications such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) (Gaffar et al., 2021). The movement originated in the early 1990s, driven by heightened environmental consciousness and the imperative for sustainable development in institutional infrastructure. This movement represents a deliberate departure from conventional library models, placing a renewed emphasis on ecological stewardship, energy efficiency, and user well-being (Guruprasada, 2024). Libraries like the Anna Centenary Library in Chennai and the Perma Karpo Library in Ladakh are examples of architectural and operational models that reflect sustainability goals. Simultaneously, digital transformation in libraries, through the digitisation of resources, use of cloud services, and virtual access, has contributed to sustainable operations by minimising the need for physical infrastructure and reducing material consumption (Vijesh et al., 2024; Robertsone & Lapiņa, 2023). Digital libraries support SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure), enabling greater access to information while mitigating environmental degradation.

Against this backdrop, this paper reviews the literature on green and digital transformations in libraries, particularly in public and academic institutions. By focusing on Indian and international case studies, it assesses existing practices, identifies challenges, and proposes strategies to enhance sustainability through library systems. The paper adopts a descriptive approach and is structured to provide both thematic insights and practical directions for embedding sustainability in library infrastructure, services, and policy.

2. UNDERSTANDING SUSTAINABILITY IN LIBRARIES

Sustainability in libraries encompasses the integration of environmental, economic, and social dimensions into library infrastructure, services, and community roles. It reflects the library's contribution to the United Nations Sustainable Development Goals (SDGs) by fostering environmental awareness, reducing resource consumption, promoting inclusivity, and ensuring long-term access to information.

2.1. Environmental, Economic, and Social Sustainability

According to the International Federation of Library Associations and Institutions (IFLA), a green and sustainable library is one that actively reduces its environmental impact, promotes a sustainable economy, and ensures social inclusion. This includes decreasing emissions through green buildings and equipment, using environmentally friendly operational practices, and implementing circular economy models like reuse and resource sharing. Libraries that adopt these principles often provide shared spaces and devices, promote environmental literacy, and create a positive carbon handprint through efficient, community-oriented services (IFLA, 2022).

On the social front, sustainable libraries contribute to education, literacy, cultural exchange, and social equity. They serve as inclusive spaces that support community engagement, bridge digital divides, and foster participation across socio-economic and cultural backgrounds. Libraries also play a key role in supporting SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action) through both physical and digital means (UN SDGs, 2024).

2.2. Libraries and the UN Sustainable Development Goals (SDGs)

Libraries are strategically positioned to support the SDGs through access to information, community development, and environmental consciousness. The UN Agenda 2030 highlights education, gender equality, climate resilience, and sustainable urban infrastructure as essential goals, many of which intersect with the core functions of libraries. For example: SDG 4 emphasises inclusive, equitable education and lifelong learning, which libraries facilitate through open access resources and literacy programs; SDG 11 promotes resilient and inclusive cities, where libraries act as safe, green, and accessible civic spaces; SDG 13 focuses on climate action, where libraries engage in environmental advocacy, awareness, and sustainable operations.

By aligning their missions and practices with these goals, libraries not only support global development

targets but also position themselves as agents of transformation within their communities. The growing emphasis on sustainability thus reshapes the purpose of libraries, from being knowledge repositories to becoming proactive platforms for change in the face of global environmental and social challenges (UN, 2024; IFLA, 2022).

3. GREEN LIBRARY PRACTICES IN PUBLIC AND ACADEMIC LIBRARIES

Green library practices involve the adoption of environmentally sustainable approaches in both the infrastructure and daily operations of libraries. These practices aim not only to reduce environmental impact but also to serve as educational models that inspire communities toward sustainability. In both public and academic settings, libraries have begun to implement strategies that align with green principles through thoughtful design, responsible resource management, and educational outreach. Public libraries play a crucial role in fostering social equity and inclusion, key components of sustainable development. As emphasised by Panda and Das (2022), public libraries are instrumental in reducing information poverty and supporting marginalised communities such as women, the elderly, and people with disabilities. A study conducted by Poluru (2019) illustrates how academic libraries, especially within design and technical institutions, are evolving into active knowledge hubs that contribute to sustainability not only through traditional services like access and dissemination, but by fostering interdisciplinary collaborations. These libraries increasingly serve as spaces for ideation, research, and community engagement, making them central to the institutionalisation of sustainability goals.

3.1. Eco-friendly Infrastructure

Sustainable library infrastructure begins with the design and construction of buildings that reduce energy consumption and use environmentally friendly materials. Libraries such as the Anna Centenary Library in Chennai have received LEED Gold certification for their efforts to incorporate natural lighting, ventilation, and energy-efficient systems into their design (Patil & Jani, 2024). Similarly, the Mumbai and Madras University Libraries integrate open layouts and naturally ventilated spaces that reduce the dependency on artificial lighting and air conditioning (Gaffar et al., 2021). The Perma Karpo Library in Ladakh, set in the Himalayan region, employs solar panels and passive heating techniques to maintain indoor comfort. The Delhi University Library System (DULS) has modernised its infrastructure with digital knowledge centres and internet-enabled facilities, demonstrating the integration of technological sustainability within architectural frameworks (Patil & Jani, 2024).

3.2. Resource Management and Waste Reduction

Libraries play a significant role in resource conservation by reducing paper use, managing waste, and encouraging recycling. Transitioning to paperless systems, issuing digital receipts, and promoting the use of electronic resources such as e-books and journals are critical in minimising the ecological footprint. In India, institutions like NIT Silchar and Calcutta University Library have developed systems to provide access to thousands of digital resources via local networks and OPACs, reducing the reliance on printed materials (Patil & Jani, 2024). Recycling programs, sustainable procurement policies, and the use of biodegradable supplies in library operations further contribute to environmental goals. By digitising collections and promoting cloud storage, libraries reduce physical clutter and energy-intensive storage systems.

3.3. Promoting Environmental Literacy

Green libraries are not limited to infrastructure but also encompass sustainable services and proactive librarian engagement in raising awareness and fostering community participation (Bangar, 2018). The libraries not only adopt sustainable practices internally but also engage in environmental education. Through exhibitions, workshops, partnerships with environmental organisations, and curated reading lists, libraries promote environmental awareness and sustainability literacy among users. This is evident in the efforts of eco-librarians, who advocate for climate action and implement green programming across academic and public libraries (Vasanthi, 2019; Gaffar et al., 2021). Libraries also support community-based environmental activities, like tree planting and local clean-up drives, strengthening their role as catalysts of grassroots change. As agents of social transformation, green libraries serve as both information providers and environmental stewards, inspiring sustainable living practices in the communities they serve. Through a diverse range of programs, like reading initiatives, digital literacy workshops, and targeted outreach, public libraries also empower individuals and strengthen civic engagement at the grassroots level (Panda & Das, 2022).

4. DIGITAL TRANSFORMATIONS SUPPORTING SUSTAINABILITY

The integration of digital technologies in library services has redefined the traditional role of libraries while offering new pathways to promote sustainability. Digital transformation (DT) in libraries enhances access to knowledge, reduces the environmental burden of print-based systems, and enables libraries to meet the United Nations SDGs through innovative, efficient, and inclusive services.

4.1. Role of Digital Infrastructure in Green Libraries

Digital infrastructure plays a crucial role in minimising environmental impacts through the reduction of paper use, storage needs, and transportation emissions. The Rajagiri Business School Library in Kerala, for instance, has envisioned a green library model aligned with specific SDGs such as Quality Education (SDG 4), Sustainable Cities and Communities (SDG 11), and Climate Action (SDG 13). The proposed design emphasises energy-efficient systems, digital collections, and user-centered sustainability practices (Vijesh et al., 2024). Similarly, agricultural libraries in India leverage digital tools to disseminate information on climate-resilient agriculture, organic farming, and sustainable food systems, thereby supporting SDGs like Zero Hunger (SDG 2) and Responsible Consumption and Production (SDG 12) (Panda et al., 2023). These libraries function as hybrid knowledge hubs, combining physical spaces with digital platforms to foster environmental and agricultural literacy.

4.2. Digital Transformation and Open Innovation

Digital transformation goes beyond technology adoption; it involves rethinking workflows, user services, and institutional goals. According to Robertsone and Lapiņa (2023), DT enables open innovation, allowing libraries to collaborate with external stakeholders, share resources, and co-create sustainable solutions. Cloud platforms, collaborative databases, and open access repositories expand the impact of libraries while reducing costs and environmental load. DT improves operational efficiency by automating cataloging, user authentication, and document delivery. It also supports remote access to information, which is essential during crises like the COVID-19 pandemic, while cutting down on energy-intensive commuting and physical infrastructure expansion.

Manna and Sarkar (2022), in their study, highlight how several global libraries are leveraging digital technologies not just for access but also for sustainability. Their analysis identifies a range of parameters including energy efficiency, carbon footprint reduction, acoustic and water management, and the integration of intelligent services such as chatbots and robotics. For instance, the University of Wellington Library uses renewable energy; the Fairfax County libraries digitise rare materials to reduce physical handling; and the New York Public Library incorporates AI to enhance user engagement. These initiatives demonstrate the potential of digital transformation as a catalyst for green and sustainable practices in the library ecosystem.

Despite its benefits, DT presents its own sustainability challenges. High energy consumption, e-waste from obsolete technologies, privacy concerns, and digital divides are ongoing issues (Robertsone & Lapiņa, 2023). Libraries in rural or underfunded regions may lack the resources and digital infrastructure necessary to implement or sustain green transformations. Additionally, the overconsumption of digital content, such as excessive downloading or printing, can contradict the goal of resource conservation. Hence, libraries must implement digital usage policies, promote awareness, and ensure inclusive access while balancing sustainability with user needs.

5. CHALLENGES AND OPPORTUNITIES

As libraries increasingly embrace sustainability through green infrastructure and digital transformation, they encounter a set of complex challenges. These range from funding limitations and lack of awareness to institutional inertia and digital inequities. However, they also present unique opportunities for libraries to reinvent themselves as sustainable, inclusive, and forward-thinking community institutions.

5.1. Barriers to Implementing Sustainable Library Practices

Several practical and institutional barriers hinder the implementation of green library initiatives. As Vijesh et al. (2024) note, challenges include:

- Lack of Awareness: Library staff and users may be unaware of the benefits of sustainability and the importance of green infrastructure.

- Funding Constraints: Green technologies and building designs often require significant upfront investment and long-term maintenance.
- Technical Expertise: Many libraries lack trained professionals to implement, monitor, and manage sustainable practices.
- Resistance to Change: Staff and stakeholders may resist shifts from traditional operations to environmentally responsible models.
- Space and Infrastructure Limitations: Especially in older buildings, accommodating green features like solar panels or green rooftops may not be feasible.
- Overlapping Regulations: Multiple certification frameworks like LEED India, IGBC, GRIHA, and international standards (e.g., BREEAM) may lead to confusion or difficulty in policy alignment.

Moreover, digital transformation poses its own paradoxes. Libraries adopting digital platforms often face high energy consumption, e-waste management issues, and growing digital divides, which hinder equitable access and contradict sustainability goals (Robertsone & Lapiņa, 2023).

5.2. Libraries as Sustainability Advocates and Educators

Despite these challenges, libraries remain uniquely positioned to champion sustainability. They function as community hubs, lifelong learning centres, and agents of behavioral change. For instance, agricultural libraries extend their role beyond information dissemination to training, awareness programs, and stakeholder networking. By collaborating with NGOs, educational institutions, and government agencies, they create localised, multilingual, and inclusive content to support SDG implementation (Panda et al., 2023).

Similarly, academic libraries promote sustainability through both content and design. The Rajagiri Business School Library's green initiative, for example, emphasises user engagement, sustainable policy frameworks, and environmental literacy, demonstrating how libraries can align their vision with broader environmental goals (Vijesh et al., 2024).

5.3. Reimagining Library Spaces and Services

As Jankowska and Marcum (2010) argue, academic libraries must transition from static physical repositories to adaptive and participatory learning environments. This means integrating sustainability not only in infrastructure but also in collection development, digital resource management, and institutional strategy. Libraries should incorporate measurable sustainability indicators, such as energy use, waste reduction, and digital equity, into their planning processes. This transformation offers an opportunity to reimagine the library as a flexible, inclusive, and environmentally responsible knowledge center. By embedding sustainability in their mission and practice, libraries can model the kind of systemic change needed to address climate change and societal resilience.

6. RECOMMENDATIONS

The evolving challenges of climate change, rapid urbanisation, and digital transformation demand a proactive and future-ready approach from libraries. Public and academic libraries, in particular, must evolve beyond their traditional roles to become active participants in environmental stewardship and digital innovation. The integration of sustainability principles into library operations, infrastructure, and community services is no longer optional, it is a necessity aligned with global priorities such as the United Nations SDGs.

At the institutional and policy level, there is an urgent need for national frameworks and institutional strategies that explicitly advocate for green library development. Regulatory bodies such as the University Grants Commission (UGC), the Ministry of Education, and the Indian Green Building Council (IGBC) should establish standardised guidelines and promote sustainability as a core component of library accreditation. Incorporating green metrics, such as energy efficiency, water conservation, digital equity, and environmental education, into library evaluation criteria can ensure long-term alignment with sustainable development agendas. Furthermore, universities and local governments must prioritise library sustainability in their policy planning, supported by targeted funding schemes, green building subsidies, and awareness campaigns (Patil & Jani, 2024; Vasanthi, 2019; Vijesh et al., 2024).

Strengthening green infrastructure in libraries is a key area of focus. Existing libraries should be retrofitted with sustainable materials and technologies, including rainwater harvesting systems, solar panels, energy-efficient

lighting, and proper ventilation. These features are already visible in exemplary institutions like the Anna Centenary Library in Chennai and the Perma Karpo Library in Ladakh, which demonstrate the feasibility and impact of such efforts. At the same time, libraries must fully embrace digital transformation not only to expand access but also to minimise paper consumption and reduce physical storage needs. However, this digital shift must be carefully managed to avoid unintended consequences such as increased e-waste, high energy use, or digital exclusion. Establishing sustainability indicators, measuring parameters like energy usage, environmental impact, digital accessibility, and community outreach, can help libraries monitor their progress and adjust strategies accordingly (Jankowska & Marcum, 2010; Robertsone & Lapiņa, 2023).

Capacity building is central to the success of sustainable library models. There is a growing recognition of the role of "green librarians" or "eco-librarians," who act as sustainability champions within their institutions. Training programs and professional development workshops should be regularly conducted to equip library staff with the skills required to manage green technologies, engage communities, and promote environmental literacy. Moreover, libraries must serve as hubs for community education by offering programs that raise awareness about climate change, responsible consumption, and sustainable living. Activities such as sustainability-themed exhibitions, workshops, book talks, and digital campaigns can significantly enhance public participation and environmental consciousness (Vasanthi, 2019; Gaffar et al., 2021).

One significant yet often overlooked recommendation for sustainable library operations is the adoption of green printing practices. Libraries can significantly reduce their environmental impact by using recycled paper, soy-based or low-VOC inks, remanufactured toner cartridges, and duplex printing techniques. By institutionalising eco-friendly reprographic policies, libraries can significantly lower their carbon footprint, conserve natural resources, and lead by example in promoting environmental literacy and sustainable resource use. By institutionalising eco-friendly reprographic policies, libraries can significantly lower their carbon footprint, conserve natural resources, and lead by example in promoting environmental literacy and sustainable resource use (Singh & Mishra, 2019). These practices not only help conserve resources and reduce waste but also align with SDG 12 (Responsible Consumption) and SDG 13 (Climate Action), reinforcing the library's role as a leader in promoting environmental responsibility.

Finally, Indian libraries must adopt context-sensitive strategies that reflect the country's socio-economic and geographic diversity. Rural libraries, for instance, may benefit from low-cost, energy-efficient designs and solar-powered digital kiosks, while urban libraries can lead in green infrastructure innovation. Agricultural and academic libraries can tailor their resources to support sustainable farming, education, and research. Libraries must also collaborate with NGOs, research institutions, local self-governments, and international organisations to leverage expertise, share resources, and foster collective impact. These partnerships can ensure that sustainability is not an isolated goal but a shared responsibility integrated across sectors (Panda et al., 2023; Vijesh et al., 2024). The way forward for libraries lies in embedding sustainability into their physical design, digital services, policies, and community engagement. By doing so, libraries can transform themselves into exemplary institutions that not only preserve knowledge but also inspire and model sustainable development for society at large.

7. CONCLUSION

The transformation of libraries into sustainable, forward-thinking institutions is both an imperative and an opportunity in today's climate-conscious and digitally driven world. As the analysis in this paper reveals, green and digital transformations are not mutually exclusive but are interdependent pathways that reinforce the library's evolving role in society. From eco-friendly infrastructure and energy-efficient design to digital literacy programs and environmental education, libraries across India and beyond are embracing sustainability as a core operational and service philosophy. The case studies and literature reviewed in this paper, from the LEED-certified Anna Centenary Library in Chennai to the solar-powered Perma Karpo Library in Ladakh, highlight the growing momentum for sustainable practices in Indian public and academic libraries. These institutions exemplify how environmental responsibility can be embedded in library architecture, resource management, and user engagement. Moreover, initiatives like the Rajagiri Business School Library's alignment with the SDGs and the efforts of agricultural libraries in promoting sustainable farming practices demonstrate the versatile and context-sensitive applications of sustainability in diverse library environments.

At the same time, the integration of digital transformation offers libraries new tools to reduce environmental impact, expand access, and innovate services. Yet, challenges such as limited funding, infrastructural constraints, digital divides, and a lack of institutional awareness persist. Overcoming these hurdles requires strategic planning, policy support, trained personnel, and sustained investment in green technologies and inclusive digital services.

Libraries are more than passive knowledge repositories; they are dynamic social institutions capable of driving cultural change and promoting sustainability. As this paper suggests, aligning library practices with global goals like the United Nations Sustainable Development Goals ensures their continued relevance and expands their role as community anchors, environmental educators, and innovation hubs. By embedding sustainability into every aspect of library planning and operations, libraries can serve as powerful models for climate-conscious, equitable, and knowledge-based societies.

8. STATEMENTS & DECLARATIONS

Use of AI Statement

The authors declare that they have not used generative artificial intelligence, specifically ChatGPT in the writing of this manuscript and/or in the creation of images, graphics, tables, or their corresponding captions

Conflict of Interest and Declarations:

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