Int.J.Curr.Res.Aca.Rev.2025; 13(7): 22-26

EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 13 Number 7 (July-2025)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2025.1307.004

Green Library: A Comprehensive Review of Concepts, Practices, and Emerging Technologies

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Abstract

The concept of the Green Library has emerged as a crucial paradigm in the 21st century, emphasizing environmental sustainability in library design, operation, and services. This review paper explores the historical evolution, definitions, objectives, and frameworks that shape the Green Library movement, focusing on global and Indian perspectives. It critically analyzes the integration of green building standards like LEED and GRIHA, sustainable operational practices, green collection development, and literacy programs. Additionally, the paper highlights the transformative role of emerging technologies such as Artificial Intelligence (AI) and robotics in enhancing Green Library services. Finally, the paper discusses challenges, national initiatives, and future directions for fostering environmentally responsible libraries as key agents of sustainable development.

Article Info

Received: 21 May 2025
Accepted: 29 June 2025
Available Online: 20 July 2025

Keywords

Library, Green Library, Emerging Technologies in Library, Digital Library, E-resources.

Introduction

In the wake of escalating environmental challenges such as climate change, resource depletion, and pollution, the role of institutions in mitigating ecological impacts is increasingly significant. Libraries, as knowledge centers and community hubs, are uniquely positioned to lead by example.

The Green Library movement, initiated in the early 1990s, calls for libraries to become environmentally friendly through sustainable design, green operations, and eco-oriented literacy programs. These efforts not only reduce the carbon footprint and resource consumption of libraries but also foster environmental awareness among patrons, aligning with broader sustainable development goals (Bangar, 2018; Gupta, 2020; Ingole & Kumari, 2021).

Concept and Definition of Green Library

The term "Green Library" broadly denotes libraries designed and operated to minimize cumulative ecological impacts across building design, material use, energy consumption, and service delivery. As per the Online Dictionary of Library and Information Science (ODLIS), a Green or Sustainable Library is "designed to minimize negative impact on the natural environment and maximize indoor environmental quality by means of careful site selection, use of natural construction materials and biodegradable products, conservation of resources like water, energy, paper, and responsible waste disposal and recycling" (Bangar, 2018; Gupta *et al.,* 2023).

Green Libraries embody environmental consciousness in several interlinked domains:

- **Green Infrastructure:** Utilizing sustainable building materials, green roofs, rainwater harvesting, non-toxic paints, and landscape design for ecological harmony (Ingole & Kumari, 2021).
- **Green Operations:** Eco-friendly daily practices including paper waste reduction, digitization, energy-efficient lighting, recycling, and water conservation.
- **Green Collection Development and Literacy:** Promoting environmental knowledge and designing collections supportive of sustainability education (Gupta, 2020).
- **Integration of Smart Technologies:** Employing AI, machine learning, and robotic systems to optimize resource use, automate processes, and reduce energy consumption (Gupta *et al.,* 2023).

Objectives and Importance of Green Libraries

The primary objectives of Green Libraries are to:

- Reduce environmental degradation by lowering libraries' carbon footprint.
- Conserve natural resources such as energy, water, and paper.
- Improve indoor environmental quality for health and well-being.
- Promote environmental literacy among users through green-themed collections and programs.
- Serve as role models inspiring sustainable practices within the wider community.
- Embrace emerging technologies responsibly to enhance efficiency without compromising ecology (Bangar, 2018; Gupta, 2020).

Libraries contribute to sustainable development by reducing operational costs through energy savings, promoting digital access, and creating awareness.

As community centers, they play an educational role by advocating green living habits and disseminating sustainable development knowledge.

Green Building Standards and Evaluation Frameworks

A foundational element of Green Libraries is the application of sustainable building standards that offer objective criteria to guide construction and operations:

LEED (Leadership in Energy and Environmental Design)

LEED is the most widely recognized certification system, developed by the U.S. Green Building Council. Its rating system evaluates buildings on categories such as:

- Sustainable site selection
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design process (Bangar, 2018; Gupta, 2020)

LEED certification levels include Certified, Silver, Gold, and Platinum based on earned points.

GRIHA (Green Rating for Integrated Habitat Assessment)

Developed by The Energy and Resources Institute (TERI), GRIHA is India's indigenous rating tool aligned with Indian climatic and cultural concerns. It assesses:

- Sustainable site planning
- Construction management
- Energy efficiency
- Water management
- Waste management
- Indoor environment comfort
- Socio-economic strategies (Gupta, 2020; Ingole & Kumari, 2021)

GRIHA offers star-based certifications highlighting sustainability credentials in an Indian context.

Elements and Features of Green Libraries

Green Libraries are focused on several interdependent elements:

Green Infrastructure

- **Site location:** Strategic urban or campus placement facilitating public transit access.
- **Building materials:** Use of recycled, locally sourced, and non-toxic materials decreases embodied energy and pollution.

- **Energy Conservation:** Solar panels, wind turbines, energy-efficient HVAC systems, LED lighting, and motion sensors reduce consumption.
- **Water Conservation:** Rainwater harvesting, sensor taps, and efficient landscaping promote responsible water use.
- **Indoor Environmental Quality:** Ventilation, natural lighting, low-VOC paints, and air quality monitoring ensure healthful environments (Bangar, 2018; Ingole & Kumari, 2021).

Green Practices and Operations

- Recycling and donation of old books and materials.
- Digitization to reduce paper dependence.
- Use of eco-friendly cleaning and office supplies.
- Waste segregation and minimal plastic use.
- Promotion of energy-saving behavioral norms for staff and users.
- Adoption of green IT solutions and library automation to optimize energy use (Gupta, 2020).

Green Collection Development and Literacy Programs

Libraries curate sustainable development resources and organize educational programs, competitions, and campaigns to raise ecological awareness and foster behavioral change among communities (Gupta, 2020).

Smart and Innovative Technologies

The infusion of Artificial Intelligence (AI), robotics, and machine learning supports Green Libraries by:

- Automating routine tasks (sorting, shelving) to optimize human resources.
- Offering AI-powered user assistance tools increasing service efficiency.
- Using data analytics to streamline collection management, optimize resource procurement, and personalize services.
- Incorporating sensor-based controls and IoT for lighting, temperature, and air quality management, significantly cutting energy use (Gupta *et al.,* 2023).

Role of Artificial Intelligence and Robotics in Green Libraries

Recent scholarship highlights the transformative potential of AI and robotics in achieving Green Library goals (Gupta *et al.,* 2023):

- **Cataloguing and Classification:** AI expert systems and natural language processing improve accuracy and speed.
- **Collection Development:** Machine learning models predict demand, aiding efficient resource allocation.
- **Information Retrieval:** Intelligent virtual assistants and chatbots assist patrons 24/7.
- **Automated Book Handling:** Robots equipped with RFID technology facilitate book identification and delivery, reducing operational energy.
- **Indoor Environment Monitoring:** AI integrated with IoT devices monitors air quality, lighting, and energy consumption to maintain optimal conditions while saving resources.

These innovations not only reduce human error and labor but enhance user experience and library sustainability.

Green Library Initiatives and Status in India

India's Green Library Movement is advancing through national and institutional efforts (Bangar, 2018; Gupta, 2020):

- **Pioneering Green Libraries:** Anna Centenary Library (Chennai), Karnataka University Library (Dharwad), Mumbai University Library, and others utilize sustainable architecture, natural ventilation, daylighting, and energy conservation systems.
- **Government and NGO Roles:** TERI and IGBC facilitate certifications like GRIHA and promote green building practices; COSTFORD emphasizes sustainable development in library infrastructure.
- **Statistical Overview:** Studies show varied adoption rates, including 22% green building presence (with 1% certified), 60% using natural daylight, 48% employing LED lighting, and only 7% with occupancy sensors, pointing to opportunities for deeper penetration (Gupta, 2020).

8. Challenges in Implementing Green Libraries

Despite advantages, Green Libraries face several challenges:

- **Financial Constraints:** Infrastructure upgrades and technology acquisition require significant investment, often limited in public and academic libraries.
- **Technological Literacy:** Rapidly evolving technologies demand specialized skills, requiring comprehensive training for library staff.

- **Job Security Concerns:** Integration of AI and robotics raises anxiety over employment displacement among librarians.
- **Policy and Awareness Gaps:** Absence of standardized guidelines for operational green practices beyond architectural certifications.
- **Scalability:** Diverse geographic and climatic contexts in India require region-specific adaptations of green practices (Gupta *et al.,* 2023; Bangar, 2018).

Strategic Recommendations

To overcome challenges and foster Green Libraries:

- Government mandates and funding incentives to promote green certifications in academic and public libraries.
- Inclusion of green library concepts and emerging technologies in LIS curricula to build professional competencies.
- Development of standardized assessment tools encompassing green practices, literacy, and technology use.
- Encouragement of collaborative efforts among libraries, environmental organizations, and technology providers.
- Awareness campaigns leveraging social media to popularize sustainable library practices.
- Incremental adoption of AI and robotics, ensuring staff retraining and role redefinition (Gupta *et al.,* 2023; Bangar, 2018).

Conclusion

The Green Library movement represents a convergent response to the environmental challenges facing global society. It redefines libraries as sustainable environments that conserve resources, exemplify ecological responsibility, and champion green literacy.

The integration of evolving technologies such as Artificial Intelligence and robotics amplifies libraries' capacity to operate efficiently and sustainably.

In India and worldwide, Green Libraries are not only saving energy and costs but playing pivotal roles in social education and sustainable development advocacy. Continued research, policy support, technology adoption, and professional education will be crucial for advancing this transformative agenda.

With the urgency of climate action, Green Libraries stand as beacons of environmental stewardship, knowledge dissemination, and community leadership in shaping sustainable futures.

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How to cite this article:

Dushyant Verma and Tagaram Choudhary. 2025. Green Library: A Comprehensive Review of Concepts, Practices, and Emerging Technologies. *Int.J.Curr.Res.Aca.Rev.* 13(07), 22-26.
doi: https://doi.org/10.20546/ijcrar.2025.1307.004