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How Academic Libraries in Asia Support the SDGs through Green Innovation: A Systematic Literature Review

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ABSTRACT

Libraries as a means of supporting education and providing access to information are now part of the implementation of sustainable development goals set by the United Nations since 2015. This study explores how universities in Asia are implementing sustainable development through the concept of green libraries. This study uses the Systematic Literature Review (SLR) method by collecting, analyzing, and reviewing all articles on the topic of green libraries in Asian countries. A total of 32 articles were selected from various databases such as Google Scholar, Emerald, and Scopus with a publication period from 2015 to 2025. The articles were selected based on the credibility of their sources, namely Sinta-accredited journal articles, reputable international journals, and international proceedings. The results of the study show a number of steps that have been taken by university libraries in various countries such as China, Hong Kong, India, Turkey, and several ASEAN countries such as Indonesia, Malaysia, the Philippines, and Thailand. The green library concept is not only referring to the physical building in the form of greening, pollution reduction, sanitation and lighting systems, to innovations in waste recycling systems, but also to technological innovations in running libraries that support their information services. All findings show that libraries, through their green innovations, have supported SDG programs 4, 11, 12, and 13, all of which require governance and cooperation as mandated by SDG 17.

INTRODUCTION

The sustainable development program launched by the United Nations in 2015 is actually a continuation of the Millennium Development Goals launched in 2000. This program initially

focused on efforts to reduce poverty, reduce HIV/AIDS, and provide basic education in developing countries (De la rosa & Domingues, 2022). Only later did a number of proposals emerge to design more inclusive programs that did not focus solely on development figures (Woodbridge, 2015). A total of 17 program goals were finally agreed upon in 2015 by all UN member states as a sustainable development program. Quoted from the UN page on Sustainable Development (sdgs.un.org), these program goals include: 1) no poverty, 2) zero hunger, 3) good health and well-being, 4) quality education, 5) gender equality, 6) clean water and sanitation, 7) affordable and clean energy, 8) decent work and economic growth, 9) industry, innovation, and infrastructure, 10) reduced inequalities, 11) sustainable cities and communities, 12) responsible consumption and production, 13) climate action, 14) life below water, 15) life on land, 16) peace, justice, and strong institutions, 17) partnerships for the goals.

Exactly ten years after its launch, this sustainable development achievement index shows that European countries have achieved the highest levels of achievement. Evidently, 19 European countries are on the list of the top 20 countries in the SDG index. Based on data from the 2025 Sustainable Development Report, Finland is the country with the highest development achievement index, followed by Sweden, Denmark, Germany, and France in the top five (Sustainable Development Goals, 2025). However, this does not mean that a number of European countries do not have obstacles. Some of the obstacles faced by a number of European countries in this SDG program are related to climate and biodiversity.

A number of countries in Asia have also shown good progress in this program. Based on the same report, a number of countries in East Asia and South Asia have shown significant progress in achieving the SDG program. China is ranked 49th and India is ranked 99th, each included in the top 50 and 100 countries with the best performance. When viewed based on the program's objectives, a number of countries in Asia have experienced significant improvements in the areas of healthy and prosperous lives, quality education, clean water and proper sanitation, clean and affordable energy, and economic growth.

Libraries, as institutions whose main role is to provide access to information and knowledge to the public, certainly have a major contribution to several of these sustainable programs, including a number of libraries in Asian countries. The millions of pieces of information and knowledge collected and managed by libraries can certainly be a source of learning for visitors according to their individual needs. Knowledge can indeed be formed from a person's efforts to evaluate and combine experiences and new information (Kamelia, 2022). Indirectly, libraries support the realization of quality education and even industrial development, innovation, and infrastructure.

In terms of information services, libraries are institutions that are always open to all groups of people, with no restrictions on certain groups of society, especially marginalized communities. This is in line with sustainable development programs related to efforts to reduce inequality. In addition, social inclusion programs in libraries also support the creation of justice and strong institutions. Social inclusion programs globally actually began in the early 1990s. Although they were never officially launched globally, these programs were born as an extension of more massive library programs. Some of their implementations include libraries providing learning

spaces, job training skills rooms, and facilities that can be used by the community (Pratiwi & Heriyanto, 2022). Meanwhile, in Indonesia itself, social inclusion-based library programs were officially introduced in 2016 by the National Library of the Republic of Indonesia. Some of the programs at that time focused on providing equal access to knowledge for the community, skills training, and community involvement in related activities at the library.

Equally important is the contribution of libraries through green library innovations. The concept of a green library itself has a fairly broad meaning. Simply put, it can be interpreted as an environmentally friendly library, but it can also mean something whose structure is designed, built, and operated so that it can be repurposed in a way that is efficient for the environment and resources (Pagore & Chalukya B V, 2022). A green library is more than just a physical space concept; it is also a holistic approach to environmental management that includes resource management, community involvement, and harmonious and sustainable programming (Toriste et al., 2024). This is the focus of this study, where the implementation of a green library can be an innovation that supports sustainable programs.

The selection of university libraries was used as a consideration for the number of innovations occurring in the university environment, including in terms of library management. Universities play an important role in addressing global environmental issues, as their involvement in education, research, and community service can have a long-term impact on the environment and society. University libraries are generally closely associated with innovation and rapid development (Demirtas Dogan & Gurpinar, 2023). Collaboration between libraries in many research processes will technically develop the competencies and capabilities of librarians (Harahap, 2024), including in terms of innovation. In addition, the momentum has grown stronger in university libraries thanks to the high demand from the entire academic community. After all, the large number of academics in the university environment has indirectly led to several recent innovations, including in library development to support sustainable programs. University libraries in Asia, as a population of green innovators, have developed a research direction examined in this study. A systematic literature review (SLR) of this research direction is ultimately guided by the research question: how can the implementation of green innovations in university libraries in Asia support sustainable development programs?

This SLR approach is certainly not merely a summary of existing literature, but rather serves as a tool to present scattered findings into a coherent and meaningful whole. Therefore, this study aims to classify the implementation of green innovation concepts by university libraries in Asia. It is crucial to examine how libraries with varying levels of technological advancement and socioeconomic conditions ultimately implement the concept of green innovation. By classifying these implementations, it is hoped that libraries in Asian countries that implement similar concepts can identify and adopt strategies most relevant to their institutional characteristics. Current research on green innovation still focuses on single case studies in specific countries. Therefore, this study aims to fill this gap by providing a comprehensive overview of green innovation concepts implemented by university libraries in Asia. A structured synthesis will make it easier for academics and practitioners to assess the extent to which these sustainability practices have been implemented, as well as their effectiveness and diversity.

LITERATURE REVIEW

The process of adaptation of university libraries to current developments in information technology is quite high, as evidenced by the many innovations and improvements in library programs at many universities. Their role is clearly very strategic in supporting the goals of sustainable development. Based on a report by the International Federation of Library Associations and Institutions (IFLA), libraries have a role as agents of change in overcoming information inequality, strengthening information literacy, and promoting quality inclusive education (Fresnido & Esposo-betan, 2018). These points are in line with a number of SDG programs. A literature review study was conducted to measure the extent to which university libraries have contributed to sustainable development programs. This research was conducted in several institutions on various continents, with the results showing that the majority of these papers represent institutions located in Asia (26.32%), Africa (21.05%), International (15.79%), Europe (10.53%), North America (5.26%), and Oceania (5.26%) (Dabengwa, 2025). Based on these research results, a number of Asian countries have a fairly high tendency as regions whose university libraries contribute to the SDGs. However, countries in the Asian region, as a region with high economic and social diversity, present their own dynamics in the implementation of SDGs in the higher education sector.

Simply put, green innovation means incorporating environmental issues into the strategic plans of every industrial institution. Green innovation can be technological or non-technological (organizational, institutional, or marketing-based) and can be driven by economic or environmental influences based on the need to balance the interests of shareholders and stakeholders (Calza et al., 2017). The concept of green innovation is not actually a new concept; it has been around for a century, first emerging as a form of concern about climate and environmental change. The increasing public demand for green innovation has led many companies, especially in the manufacturing industry, to shift their priorities from efficient production to environmentally friendly production (Cisneros Chavira et al., 2023). Green innovation itself can be interpreted as the promotion and development of products, services, and ecological processes that contain a certain degree of novelty. It consists of new innovative ideas that aim to provide products or services without damaging nature, preserving the environment, and being ecological in their conception, construction, use, and disposal (De la rosa & Domingues, 2022). In the context of the manufacturing industry, green innovation can include a combination of green product innovation and green process innovation, activities that simultaneously reduce pollution and improve environmental performance (Ogiemwonyi et al., 2023).

Some concrete examples of its application are the use of solar panels at a law firm in Spain (Bataineh et al., 2024), efforts to combat plastic waste in the oceans in several countries in the Americas (Schmaltz et al., 2020), and even a number of countries in Europe have entered into a number of green agreements launched by the European Commission in 2019 (Cisneros Chavira et al., 2023). Among these agreements are: 1) fresh air, clean water, healthy soil, and biodiversity, 2) renovated and energy-efficient buildings, healthy and affordable food, 3) more public transportation, 4) cleaner energy and cutting-edge clean technology innovations, 5) more durable

products that can be repaired, recycled, and reused, 6) jobs and skills training that are future-proof for the transition, and 7) globally competitive and resilient industries.

Green innovation in this study refers to the definition of green innovation as the application of technology, policies, and operational practices aimed at reducing the environmental impact of library activities (Tariq et al., 2025). The Online Dictionary for Library and Information Science (ODLIS) defines a green library as a library designed to minimize negative impacts on the natural environment and maximize indoor environmental quality through careful site selection, use of natural building materials and biodegradable products, resource conservation (water, energy, paper), and responsible waste disposal. Several other sources also mention the term green library, which refers to the concept of a library that incorporates environmentally friendly and sustainable practices into its design, operations, and services (Toradmal, 2025). Another term for green library refers to the concept of green buildings with various elements, ranging from air ventilation, temperature, and the environment outside the building (Afacan, 2017). Libraries, traditionally known for their role in disseminating knowledge, can now also be examples of environmental management that must be carried out (Ganesamoorthy & Selvakamal, 2025). It is fitting that libraries, as centers for the dissemination of information, directly implement the concept of green innovation in their institutions. The information conveyed is not only news from outside that is conveyed by the library, but also directly shares what the library is doing in its efforts to achieve environmental and climate balance.

METHODOLOGY

This study uses the Systematic Literature Review (SLR) method by identifying, evaluating, and synthesizing a number of scientific literatures related to how university libraries in Asia support sustainable development goals through green innovation programs implemented in each library. This method was chosen to ensure objectivity, reproducibility, and comprehensive coverage of the collected literature. This method is used for studies that aim to identify all empirical evidence that meets predetermined inclusion criteria to answer specific research questions or hypotheses (Snyder, 2019). Research with SLR methodology must explicitly and transparently report the steps of the search process (Williams et al., 2020). It is the results of this search that are used to reinforce perceptions and generate research conclusions, not the results of the researcher's assessment or opinion.

The research design used the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) model. Used as a step in writing a complete protocol or review report and completing a checklist, PRISMA is likely to provide readers with information about what the authors did and found, but it will also optimize the quality of reporting and make the review process more efficient (Sarkis-onofre et al., 2021). This model will be used to answer the research question of how the implementation of green innovations in Asian university libraries can support sustainable development programs. The database used for this study consists of a number of articles selected based on the credibility of their sources, namely Sinta-accredited journal articles, reputable international journals, book chapters, and international proceedings. Some of the databases used are Google Scholar, Emerald, and Scopus with a publication period from 2015 to 2025.

Inclusion and Exclusion Criteria

A number of criteria were established in the keyword search. These criteria helped the systematic literature review process produce data that was accurate and relevant to the research needs. Some of the criteria used included publication date, publication type, language, and publication access. Table 1 shows a number of criteria that are included and excluded in the search parameters related to how university libraries support SDG programs through green innovations implemented in various countries in Asia.

Tabel 1. The Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Time	2015 - 2025	Before 2015
Publication Type	Journal article, proceeding	Newspapper, books, book chapter
Languages	English and Bahasa	Other Languages
Access	Full-Text Access	Incomplete Text Access
Completeness	With abstrak	Without abstrak

Data Collection and Analysis

The article search and collection process was conducted systematically following the PRISMA framework. In the initial stage, articles were searched for by identifying databases using variations of the keywords “academic libraries” OR “university libraries” AND “Asia” AND (“green innovation” OR “sustainable innovation” OR “eco-friendly initiatives”) AND (‘SDGs’ OR “Sustainable Development Goals” OR “sustainability”) (“library sustainability” OR “green library”) AND “Asia” AND (“SDGs” OR “Sustainable Development Goals”) (“environmental initiatives” OR “resource efficiency” OR “waste reduction”) AND “academic libraries” AND “Asia” AND “SDGs”. In addition, several terms used, namely ‘libraries’ and “green library,” were also considered. Based on the literature review, 209 articles were identified that provided a broad overview of green innovation in libraries.

Before conducting the screening, initial data cleaning was performed to ensure the articles to be reviewed were of high quality. Several data points were removed prior to screening, resulting in the identification of 19 duplicate articles. In addition, 65 articles did not meet the publication year requirements, which should be between 2015 and 2025. Then, 13 articles were found to be unindexed in Scopus (Q1, Q2, Q3, Q4) or unaccredited, and 9 articles lacked abstract notes. Based on this data, 103 articles were excluded prior to screening as illustrated in Figure 1.

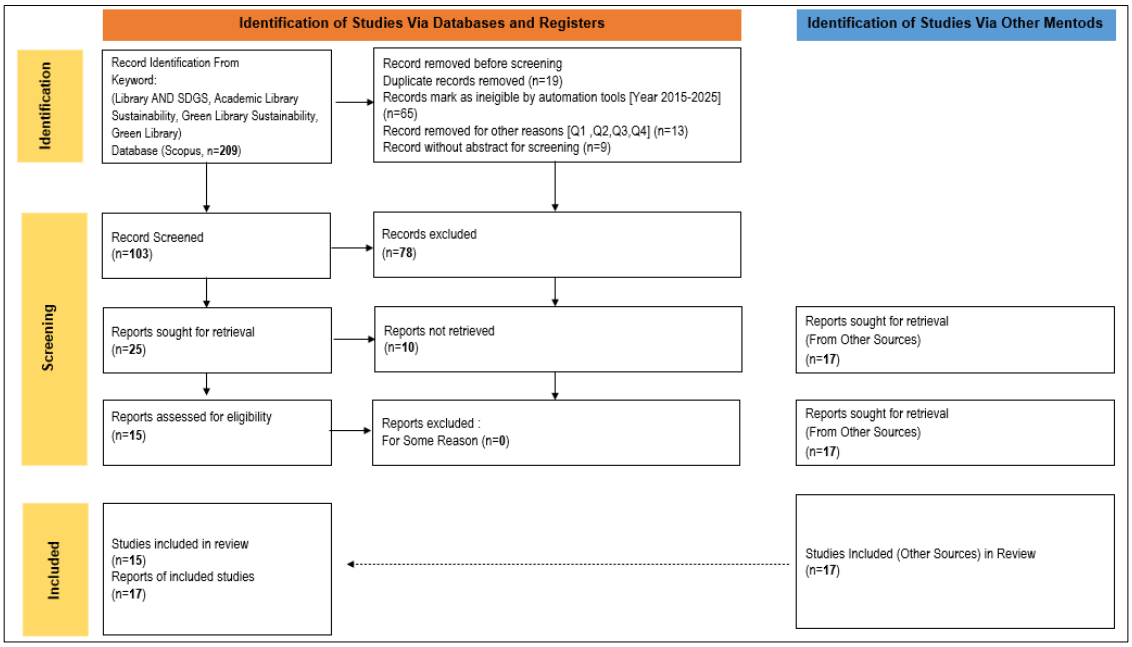

Figure 1. The Flow of Publications through Different Stages of the Systematic Literature Review

Based on the findings from the 103 articles, screening focused primarily on the suitability of the topic. In addition, the articles selected for review had to be in English. As a result, 78 records were excluded because they did not meet the criteria for topic suitability or language. From this process, 25 documents remained. After further searching, 10 reports were found to be inaccessible (not retrieved), leaving only 15 reports for in-depth feasibility assessment. To enrich perspective and analysis depth, additional sources beyond the main database were searched, yielding 17 articles that will also be analysed. From a series of article selection processes, 32 articles were used in this study.

To ensure the 32 articles were of high quality, a content quality assessment was conducted using the CASP checklist. This method was used to ensure that the articles reviewed had valid, accurate, and relevant data for this study. The assessment results showed that all articles demonstrated clear clarity in formulating research questions relevant to the application of green innovation in Asian libraries. The research designs of the 32 articles also harmonised green innovation practices in libraries with the SDG goals. Thus, all articles used in this study were of good quality.

All articles found were analyzed based on their content context. The main consideration was the suitability of the literature theme to the research objectives. The writing style, content, and completeness of the discussion in the literature were also taken into consideration. In the context of how university libraries support sustainable programs, considerations regarding the implementation of activities included in green innovation were also important and were used as

notes on the findings. In addition, the limitation of the research, which focused on the achievements of sustainable programs in the Asian region, was clearly also a consideration in the selection of literature whose topics discussed cases of university libraries in countries in the Asian region. It is this synthesis of themes that will ultimately be used to answer the research questions, so as to provide a systematic overview of the research topic.

RESULTS AND DISCUSSION

This study reveals various green library initiatives implemented by universities in Asia as a form of support for the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 13 (Climate Action), SDG 12 (Responsible Consumption and Production), and SDG 11 (Sustainable Cities and Communities). The references reviewed represent different approaches, but all emphasize the institutions' commitment to environmental sustainability through the role of libraries. The support of university libraries in Asia for the Sustainable Development Goals (SDGs) through green innovation is no longer just a policy jargon, but has developed into interrelated strategic, technological, and cultural practices. As a conceptual basis, the green library movement emphasizes that sustainability is multidimensional—environmental, social, economic, and cultural—so that the library's approach should not stop at building energy efficiency alone, but also include services, literacy programs, and governance (Di Domenico, 2020). The IFLA agenda and initiatives provide a broad normative reference framework for linking library functions to SDG targets, while positioning librarians as agents of change in policy and service architecture (Narendra, 2023; Di Domenico, 2020). At the level of definition and work domain, the concept of green librarianship and indicator areas (strategy, buildings, equipment, collections, services/programs, staff competencies, partnerships) help map the scope of interventions relevant to university libraries (Fedorowicz-kruszewska, 2020). On the other hand, the literature also highlights that the conceptual construction of green libraries at the global level still faces ambiguity in definitions, the absence of standard indicators, limitations in power and energy efficiency, and weak monitoring of SDGs in national policies (Fedorowicz-kruszewska, 2020). In the research landscape, the bibliometrics of “green libraries” show relatively consistent thematic clusters—energy-efficient buildings, green policies/strategies, and services and education—with dominant contributions from the United States and China, but cross-country collaboration remains low (S. Li & Yang, 2022).

An analysis of 32 relevant studies was conducted by identifying the activities carried out by university libraries in Asia, which were implemented with a focus on sustainable development. A number of findings were discovered in the form of strategic innovations and practices implemented by these university libraries. Figure 2 shows the pattern of findings on the implementation of green innovations in several libraries in Asia. The technical aspects of buildings, governance, and digital services are findings from a number of literature sources that form the three pillars of green innovation in university libraries in Asia.

Implementation	Countries	Innovation discovery patterns	Supported SDG categories
▪ Librarian outreach on green initiatives (reducing energy consumption) ▪ User-based environmental education ▪ Several activities for supporting literacy and lifelong learning	Turkey Indonesia Yordania India	Service and Program Innovation	SDG 4: Quality Education
▪ Provision of digital resources (paperless) ▪ Digitalization and automation systems	Almost all Asian Countries	Technological Innovation	SDG 4: Quality Education
▪ Temperature control system (especially during extreme temperatures), gas, lighting, and electricity ▪ Rainwater utilization system	China	Building and Construction Innovation	SDG 11: Sustainable Cities and Communities
▪ Green buildings (water elements, energy conversion, building design, local resources) ▪ Use of recycled materials and resources ▪ Electricity and water conservation ▪ Waste sorting, solid waste collection ▪ Use of natural materials: wood, wool, solar panels, bamboo (as a substitute for steel) ▪ Use of paper insulation, plants on the roof ▪ The green concept is to create open spaces, large windows	Philipine Turkey India Malaysia China	Building and Construction Innovation	SDG 12: Responsible Consumption and Production SDG 13: Climate Action
Findings in several Asian countries on the involvement of cooperation partners in implementing green innovations.		Management (cooperation and policies)	SDG 17: Partnerships for Goals
Assessment and evaluation instruments	Philipine Malaysia South Korea	Evaluation	Green library sustainability measurement tool

Figure 2. Activities that Support Sustainable Programs through Green Innovation in Libraries

The mapping pattern of green library implementation in several university libraries in Asia is basically divided into four (4) groups of innovations, including 1) innovations in services and activity programs, 2) technological innovations, 3) innovations in infrastructure (buildings and structures), and 4) innovations related to the management and evaluation of green libraries themselves. The first group of innovations in services and activity programs is generally carried out by empowering librarians and implementing environmental literacy programs. Several university libraries in Turkey and India have implemented information literacy programs linked to environmental awareness, ranging from the use of information technology and databases to the utilization of digital resources. (Demirtas Dogan & Gurpinar, 2023; Sandesh & Vanikar, 2023; Sivaprasad et al., 2024; Vijesh et al., 2024). A similar situation has also occurred in several university libraries in Hong Kong and Bangladesh, where all daily library services have been shifted to online services via email for borrowing, thereby reducing the amount of paper used. (Jones & Wong, 2016; Tanzin & Hoq, 2024).

Other services related to sustainable development efforts include literacy programs, both general environmental literacy and green information literacy, which will foster resource-efficient behavior and climate change awareness, especially among academic communities (Fedorowicz-kruszewska, 2020; Naik, 2024). Other information literacy programs have also emerged under the term eco-literacy, with seminars, workshops, and several exhibitions related to the environment. Several countries in Asia, such as India, Sri Lanka, Indonesia, and Thailand, have made efforts to introduce environmental conditions to the public through literacy programs that

include workshops on environmental awareness campaigns, waste sorting movements, waste bank education, plastic bottle reduction, and efforts by university libraries to procure collections related to climate and the environment (Naik, 2024; Panda et al., 2025; Sivaprasad et al., 2024; Sulaiman & Laksmi, 2024; Vijesh et al., 2024). One university library in India even created a gardening community and sustainability workshops based on the Greening Libraries concept. (Ritu, 2024).

This activity is not actually an innovation; several other countries have also implemented it. For example, the Talking Truth at the Library Project in the United States was carried out through discussions, storytelling, and a contemplative pedagogical approach to raise public awareness about climate change. Introducing environmental conditions to children through the Library ECOStyle in Ukraine, as well as utilizing unused public spaces (e.g., old public telephone boxes) to introduce environmental literacy, has also been done by several libraries in Germany (Di Domenico, 2020). The provision of free books to increase reading interest is carried out at several points easily accessible to the public, including remote areas and pedestrian paths, through street libraries in Jordan (Tbaishat, 2020). Of course, locations close to public transportation will indirectly help reduce carbon emissions from other private vehicles (SDG 11 and 13). Even nearby locations allow library visitors to use bicycles or walk. This effort is, after all, part of library service innovation that can help reduce carbon emissions and pollution when the community seeks to access the library's collections.

Still related to services, several university libraries have also made librarians a main focus in their efforts to support environmental sustainability. A study was conducted across 14 university libraries in China, one of whose results showed the important role librarians play in raising awareness of green libraries. Librarians are not merely service providers but agents of change, drivers of environmental awareness, and proponents of green policies at the organizational level (Kang, 2018). Another study was also conducted on 11 university libraries in Istanbul and Kocaeli. The results showed that 7 of the 11 libraries were classified as green libraries, with one of their innovations being to make librarians agents of education and environmental behavior change (Demirtas Dogan & Gurpinar, 2023). Although no research results were found in other Asian countries, these findings sufficiently demonstrate the importance of librarians as key resources in driving environmental awareness, both in their own libraries and in their parent institutions. The involvement of users and librarians as agents of environmentally friendly behavioral change is a potential innovation (Gupta, 2020). Other libraries could implement training programs, such as Green Leadership, to develop green leadership among students, making them future agents of sustainability (Naik, 2024).

The second finding regarding the implementation of green libraries concerns the application of technology. Libraries as institutions oriented towards information services also contribute to SDG4 (quality education) and SDG11 (sustainable cities and communities) through service innovation, literacy, and program design. The findings show that the application of technology in services and infrastructure has a significant impact on the implementation of green libraries. Although technology-based library services are not an innovation born of efforts to raise environmental awareness, they are an adaptive response to technological development. However, their implementation has an impact on environmental sustainability through green libraries. The

Shoman Library case study maps the contributions of services and programs in detail to various SDG targets, with findings showing strong contributions to education, equality, economic opportunity, and social inclusion (Tbaishat, 2020). The implementation of a green library at the Sebelas Maret University (UNS) Library Unit applies how paperless efforts in every work activity, waste sorting, and environmental education for library visitors can be mapped into roadmap requirements and systematic sustainable reporting (Haryanto et al., 2025). The same thing also happens, where digital transformation shortens the distance between users and services, reduces material consumption (paper/print), and opens up an operational data ecosystem for energy and waste management, as shown in the use of the library collection management system, SLiMS (Budianto et al., 2022).

Meanwhile, in Bangladesh, a study on the transformation of the Dhaka University Library highlights the implementation of digitization, energy efficiency in its library environment, and educational programs within it (Tanzin & Hoq, 2024). Related literature even complements this with user perceptions of the implementation of green innovations. One university library in Turkey shows that environmental education engagement increases positive attitudes and awareness, with perceptions of green innovation in institutions that have adopted greener practices more widely (Demirtas Dogan & Gurpinar, 2023). Another library is the Karnataka University Library in Dharwad, which provides green spaces for its users. The green space in question is an open space provided for group discussions and study rooms for students and is located close to all departments at the university (Gupta, 2020).

The research in this section shows that almost all university libraries in several Asian countries have implemented technology in their services, including digital literacy initiatives. This includes providing internet access and devices such as tablets and computers; using recycled cartridges; implementing RFID; digitizing collections; developing library automation systems; and developing e-books and e-journals. The integration of tens of thousands of e-books and the development of a digital repository has also been carried out by the Bangalore University Library in collaboration with the National Digital Library of India (Shivaraja, 2023). he transition of collections to e-book format, the digitization of several library materials, and the digitization of the main book are steps libraries take to reduce paper use (Banerjee & Maity, 2023; Naik, 2024). A review of research results even shows that efforts to digitize Buddhist religious texts at the Polgolla Buddhist Library have reduced paper use by 90% and increased global access to the works by 60% (Wijerathne, 2024). Therefore, even if the innovation is not novel, the application of technology in libraries has a significant impact on environmental sustainability, especially through paper savings and equipment reuse.

In the field of infrastructure, which in this case refers to innovations in buildings and structures, several university libraries have modified existing buildings and library areas. One implementation is the Transient System Simulation Tool (TRNSYS) simulation at a library in Malaysia showed that strengthening building envelopes—such as insulated cavity walls and double glazing—can significantly reduce annual cooling loads. This implementation contributes directly to achieving affordable and clean energy (SDG 7) and economic growth (SDG 13) (Khean et al., 2023). Similar technical-spatial approaches have also been implemented in various other Asian university libraries, including building envelope strategies, natural lighting,

ventilation, low-carbon footprint materials, and energy efficiency technologies (Li et al., 2018; Shivaraja, 2023; Vijesh et al., 2024; Banerjee & Maity, 2023).

Another area of energy is found in literature related to the implementation of natural lighting and temperature control in reading rooms in China (SDG 11). This literature emphasizes the importance of south-facing openings and daylight duration, which have an impact on window design and critical mass for energy conservation (J. Li et al., 2018). A study at Bangalore University Library provides a concrete example of how physical spaces can be transformed into learning ecosystems that promote environmental awareness. Through the Green Library Project, they developed green spaces filled with reading gardens, walking paths, open amphitheaters, and discussion areas under shady trees. This initiative not only creates a comfortable and healthy learning atmosphere, but also becomes a tangible form of sustainability integration in campus planning (Shivaraja, 2023). This initiative involves design elements such as pergolas, reflection paths, and open discussion spaces. The "Read and Relax" concept they promote reflects the idea that the library space is not only a place for reading, but also a space for reflection and environmental awareness for the academic community. Complementarily, the Green Library design, which is aligned with the SDGs at Rajagiri Business School, shows how physical design and service programs are explicitly directed towards SDG targets (Vijesh et al., 2024). Another implementation took place at the Chinese University of Hong Kong Library, which has a rooftop organic garden facility. Based on a survey conducted at this facility, the organic garden has proven successful as an educational tool, a team-building medium, and a way to raise awareness and support green lifestyles (Jones & Wong, 2016).

Meanwhile, several universities in Turkey such as Bogazici University (Boun), Istanbul Technical University (ITU), Yildiz Technical University (YTU), Gebze Technical University (GTU), Marmara University (MU), Istanbul Medeniyet University (IMU), Sabanci University (SU), MEF University (MEF), Koç University (KU), Istanbul Sabahattin Zaim University (IZU), and Ozyegin University (OZU) have implemented green library through several programs that have been running for a long time (Sesen & Hamdi Kuzucuoglu, 2020). First, in terms of water and energy conservation, all private universities with new building models have double-glazed windows and efficient water installations with sensor taps and dual-flush toilets. The use of double glazing helps prevent heat loss during winter and maintains heat stability during summer. This clearly contributes to SDG 13 in terms of maintaining climate stability without using a lot of energy for air conditioning or heating. The same applies to the use of dual-flush toilets. This helps regulate the amount of water used for solid and liquid waste. Sabanci University, MEF University, Koc University, Sabahattin Zaim University Istanbul, and Ozyegin University are universities that have implemented both of these measures. In addition to these specific measures, all of the libraries mentioned have implemented energy savings in their library operational systems, as well as the use of non-toxic cleaning products for rooms and toilets. This implementation proves that even old buildings can become green libraries through proper renovation and management.

Prince of Songkla University (PSU) in Thailand integrates technology for energy efficiency and emissions monitoring by introducing another dimension of the green library, namely the use of a digital carbon dashboard to monitor and report on the consumption of resources such as electricity, water, paper, and waste (Krairiksh, 2021). This practice is in line with SDG principles

12 and 13, while strengthening the role of libraries in educating communities about data-based ecological responsibility. Another green library concept can be found at the University of Mumbai Library and the University of Madras Library, where these libraries use environmentally friendly equipment made of wood as their building material, with wide windows so that sufficient light can enter the library (Meher & Parabho, 2017). In addition, these libraries provide spacious open areas for readers. More recently, the Anna Centenary Library (ACL) has combined the green concept with a modern library building. Green plants are placed at certain points that may benefit users.

The implementation of the green library concept across multiple libraries is driven by the ecological crisis and climate change, which have become global concerns, thereby placing libraries under a social responsibility to address these issues. In addition, support from institutional leaders and all users has encouraged libraries to adapt to become green libraries, as is the case at Dhaka University Library in Bangladesh. The demand for buildings to be assessed against certain evaluation standards has also become a requirement for leaders seeking to realize these green library efforts. However, it cannot be denied that budget constraints are a major obstacle to implementing this in several countries. The costs of building renovations, water conservation, and the provision of adequate green spaces are among the main obstacles to implementing green libraries (Sivaprasad et al., 2024). Many library leaders and staff understand the importance of the green library movement. Still, budget and resource constraints have led some libraries to focus on service innovation rather than on building and structural innovation n (Kang, 2018). High initial costs make it difficult for many old libraries to be adapted into green buildings without major renovations (Sesen & Hamdi Kuzucuoglu, 2020). Even libraries that have successfully implemented environmentally friendly building and construction innovations will still face obstacles, as maintaining high-tech buildings and structures clearly requires significant costs. Therefore, the commitment and support of institutional leaders are the main determinants in the implementation of green libraries. This important factor is the final finding and discussion in this study on the implementation of green libraries.

Management and evaluation of green library measurement are the latest findings from the mapping of green library implementation patterns in university libraries in Asia. Management in this research refers to the management of libraries to become green libraries through several strategies, policies, and leadership roles. Institutional innovation and partnerships are among the strategies libraries can implement to realize green libraries amid various resource constraints. Rajagiri Business School, a college library in India, collaborates with various companies through its Corporate Social Responsibility (CSR) program to instil environmental values and ethics among students (Vijesh et al., 2024). This activity can be carried out because, after all, companies always have a social responsibility to the community. Not only companies but also a number of social institutions can serve as partners, especially in organizing social inclusion activities (Panda et al., 2025). Another form of collaboration is carried out in one of the university libraries in China, where libraries share responsibility for storing a single printed copy, thereby reducing collection duplication, saving space and resources, and promoting collaboration between institutions (Jones & Wong, 2016).

Implementation of green innovations carried out in various universities in Asia is closely related to bureaucratic systems, leadership support, and surveys of academic communities in

universities. This area relates to sustainability committees, energy wardens, targets/reporting, as well as financing and partnerships that support consistent implementation (Jones & Wong, 2016; Noh, 2021; Kang, 2018). Accelerating green innovation requires mitigation strategies against structural and organizational barriers. Recurring barriers include limited initial investment funding, lack of technical capacity to design or operate sustainable systems, and an unstable evaluation institution (Sivaprasad et al., 2024; Tariq et al., 2025). This is also reflected in research findings where a comprehensive review of the barriers and drivers of green library adoption identifies funding, technical capacity, and leadership as the main determinants, while the consistently reported benefits include energy efficiency and user health (Tariq et al., 2025; Sivaprasad et al., 2024). Studies in Turkey remind us of the importance of user education so that technical strategies and policies do not operate in a social vacuum (Demirtas Dogan & Gurpinar, 2023). This means that the implementation of activities cannot move forward without the space and support of the organizational structure, which in the context of university libraries means the university environment itself. Several cases in Indian libraries, such as the Karnataka University Green Library and the Anna Centenary Library, have effectively implemented green library programs thanks to government support and community collaboration (Panda et al., 2025). Therefore, policy and leadership factors play a very important role in the implementation of green libraries. Budget allocation, priority scales, and various green library implementations are subjects that must be included in the determination of leadership direction and policy.

A study on green libraries was conducted on 14 libraries in China, which showed that relatively high green awareness does not automatically lead to consistent operational actions, because energy audits are rare, operational waste still occurs, and internal policy support needs to be strengthened (Kang, 2018). In general, the implementation of university library activities that lead to sustainable development goals is still uneven. Some countries are still focused on implementing services, and are even just starting their digitalization efforts. Meanwhile, other parts of Asia are already focusing on implementing space and building designs that support green innovation. Librarians' awareness of the sustainable development agenda and IFLA strategies is still uneven, even though the level of normative agreement on library support strategies for SDGs tends to be high; this means that there is a gap between conceptual support and implementation (Noh, 2021).

Several university libraries in Asia have adapted and developed a number of instruments to evaluate the implementation of green libraries. The simplest approach is to measure user satisfaction with a range of green library service innovations, or to use ISO-standard measurements of the impact of green library services (Di Domenico, 2020; Fedorowicz-kruszewska, 2020). Efforts to formulate an assessment tool to evaluate the implementation of green innovations in libraries, particularly those already operating in Malaysia, have also been undertaken. Some of the main criteria consist of: energy, water, waste, operations and maintenance, furniture and equipment, landscaping, spatial planning, indoor environment, transportation, and housekeeping (Ismail et al., 2022). Other evaluation indicators have also been implemented in 13 university libraries in South Korea. So far, green library assessments have mostly focused on building/architectural aspects, even though libraries also have services, collections, and programs that impact the environment. New areas that have been developed include energy and pollution prevention, indoor environment, library resources, environmentally friendly education programs, and computerization (Noh & Ahn, 2018).

The concept of life cycle assessment can also be applied to evaluate the production cycle of books, such as: availability of sustainability information, environmental commitment and compliance, materials (paper, ink, recycling), transportation, and infrastructure, as done in several libraries in Canada (Mccord et al., 2025). In addition, several global standards, such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method), can be applied to evaluate the implementation of green library buildings. India is one of the Asian countries with its own evaluation standards for measuring buildings. The Energy and Resources Institute, supported by the Indian government, has developed an assessment tool, the Green Rating for Integrated Habitat Assessment (GRIHA), which measures the sustainability of buildings against Indian national standards, including energy efficiency, water conservation, waste management, and reduced ecological impact. In addition, the Indian Green Building Council (IGBC), developed by the Confederation of Indian Industry, assesses energy efficiency, water efficiency, building materials, and occupant health (Sandesh & Vanikar, 2023).

De La Salle University, including its library, is the only educational institution building to have been assessed by Building for Ecologically Responsive Design Excellence (BERDE), a nationally recognized voluntary green building rating system. This rating system was developed by the Philippine Green Building Council (PHILGBC) and introduced in 2010. Several evaluation points consist of environmental impact, health, and building performance, while encouraging socially responsible design and construction (Blanc & Strobl, 2016).

The contribution of university libraries to SDG programs is also implemented in activities that help improve sustainable literacy, but leadership, organizational culture, and partnerships remain key to ensuring the integrity of these programs (Dabengwa, 2025). All pillars of the implementation of university library activities towards sustainable development programs through green innovation require normative legitimacy through international policy. This normative-strategic framework needs to be underpinned by the IFLA agenda and the strengthening of green literacy, so that librarians have a basis for orchestrating change within complex organizations (Narendra, 2023; Di Domenico, 2020). Thus, effective green innovation designs to support SDGs in Asian higher education environments must be built on a foundation of mutually reinforcing governance, policy, and literacy.

The practical implications of this study yielded several findings regarding the implementation patterns of green libraries across several university libraries in Asia. Although many innovations, especially technological ones, are not renewable, their implementation has a significant impact on environmental sustainability, particularly by reducing paper use and carbon emissions from transportation to the library. Meanwhile, in terms of programs and services, environmental literacy remains a mainstay activity of libraries in implementing green libraries. However, librarians' role is very important in this regard. Training librarians in environmental awareness is clearly necessary, especially as they seek to become agents of social change (Fedorowicz-kruszewska, 2023).

The implementation is quite innovative, particularly in terms of building and structural innovation. The simplest concept of saving energy by modifying buildings and structures through

technology is evident in many libraries. In particular, several countries with extreme weather conditions, such as winter in China and wind in the Philippines, are among the factors driving environmentally friendly building innovations. Finally, implementing all these green library initiatives clearly requires support from institutional leaders, especially in strategy and policy. It also requires cooperation and support from relevant organizations to overcome a number of existing limitations. Even green library innovations that have been successfully implemented require long-term evaluation and assessment tools to measure the program's accuracy and sustainability. Several findings from the measurement tools in this study can serve as a reference for any library that wishes to implement them, in accordance with the standards of its respective country.

CONCLUSION

This study has identified five patterns of green library initiatives implemented by various university libraries in Asia to support the Sustainable Development Goals (SDGs). These patterns include: service and program innovation (SDG 4), technological innovation (SDG 4), building and construction innovation (SDGs 11, 12, 13), management and policy innovation (SDG 17), and evaluation processes. The implementation of green innovation in Asian libraries shows a diversity of highly systematic approaches, ranging from behavioral change to physical infrastructure transformation. In the field of services, libraries in countries such as Turkey, Indonesia, Jordan, and India actively involve librarians in green initiatives to reduce energy consumption. These efforts are supported by user-based environmental education programs and various literacy activities that support lifelong learning. In line with the service aspect, technological transformation has become an important pillar for almost all Asian countries. The main focus is on providing digital resources to realize the paperless concept and implementing automation and digitization systems. In terms of physical infrastructure, China has made significant progress in building and construction innovation through the implementation of temperature-control systems (especially during extreme weather), lighting systems, and rainwater-use systems.

Meanwhile, in other regions such as the Philippines, Turkey, India, and Malaysia, the concept of green buildings is being applied more widely through the use of recycled materials, water and energy conservation, and natural materials such as bamboo and solar panels. Management policies are key to the success of several Asian countries in achieving sustainable development. To ensure long-term sustainability, countries such as the Philippines, Malaysia, and South Korea have developed specific assessment and evaluation instruments. These tools serve as formal evaluation instruments to monitor the extent to which green library standards have been consistently achieved. Overall, the practice of green innovation in libraries in Asia has evolved to integrate technology, infrastructure, and management policies to support the sustainable development agenda.

More broadly, this study provides an understanding that libraries can serve as a bridge between the global SDGs agenda and concrete actions on campus. Green innovation is not just about energy savings or digitization, but about building ecological awareness embedded in the behavior

of the academic community. However, further exploration by subsequent researchers is needed to determine how to overcome the financial challenges and technological limitations that libraries in smaller or developing Asian countries face when implementing complex green building standards.

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