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Green Library Initiatives in Medical Universities of Sindh: A Study of Current Practices and Challenges

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Abstract

This study was aimed at the knowledge of green library projects at the medical universities in Sindh province where the current activities levels were surveyed and also on the availability of implementation obstacles. Data was gathered using the mixed-methodology research design targeting 10 medical universities by querying them through structured questionnaires, semi-structured interviews that included direct observations. It was found that although there were fundamental energy-saving steps embraced by 60 per cent of medical universities libraries, there were few comprehensive green efforts. The use of digital resources demonstrated a high level of improvement by having 80 percent of libraries carrying out electronic databases and digital collections. But shortage of funds (90 percent of institutions), skilled individuals (70 percent) and institutional support (60 percent) were the serious problems. The libraries with formal sustainability policies were scarce (30 percent) and reduction of the waste program only found in 40 percent of the institutions. The researchers observed that publicly funded universities had smaller green practice compared to those that are privately funded and the main obstacle was the scarcity of resources. Seventy percent of the libraries had energy-efficient lighting systems and only 20 percent of the institutions used renewable sources of energy. The level of staff awareness on green practices was moderate as 65 percent of the library personnel had basic knowledge of concepts of sustainability. The study finds that although medical university libraries in Sindh have started implementing some green initiatives, a formal implementation process will need better institutional backing, clear funding market and in-depth training courses to have a significant measure in environmental sustainability.

Keywords: Green Library, Projects, Medical Universities, Sindh Province, Energy-Saving, Digital Resources.

Introduction

The notion of green libraries has become a conceptual revolution in the 21st century and this is a paradigm shift in institutional approaches involving environmental sustainability in the

information centers in academic institutions. This trend involves a full scale of activities aimed at reducing environmental burden and at the same time increasing resource productivity and instilling the ecological concerns in library patrons and employees. Embedding of green practices in the academic libraries has gained momentum due to the realization by the learning institutions globally that they have a role to play in terms of protecting the environment and ensuring sustainable development (Ajani, Tella, & Enakrire, 2024). The green library initiatives are especially important in the realm of medical universities since the sphere of healthcare education and research has a high ecological impact. Conventional medical libraries generally utilize a lot of energy in their activities due to the large-scale illumination; climate control needs to maintain delicate items and use of the various electronics devices and databases. Also, the healthcare industry focus on print, research articles, and dedicated devices provides special challenges with regard to the implementation of sustainable practices and support of high standards needed at the levels of medical research and education (Ashiq, Rehman, & Mujtaba, 2021). Since the province of Sindh is one of the most populated and economically important regions of Pakistan, it is occupied with a number of medical universities, which are centers of healthcare education and research activities. These institutions are experiencing pressure to become environmentally responsible to an increasing extent and equally offer quality educational resources and services. Climate change and environmental degradation have been on the rise and that is as a reason why academic leaders have embarked on exploring creative methods so as to minimize their carbon footprint and adopt operations that are sustainable (Rafi & Mairaj). Importance of green library initiatives goes beyond environmental awareness as it brings financial benefits such as lowered expenses of running the library, increased recognition of the institution as well as user satisfaction. The contemporary users of a library or the students and faculty of medical establishments are becoming more concerned with their libraries exhibiting environmental concerns and giving them green learning environments. This anticipation has posed an attractive argument on investing in green library operations by medical universities as an extension of their sustainability goals (Haq, 2021b). The blistering development of digital technologies opened the doors to previously unknown opportunities of libraries of environmental impact reduction with the help of e-resources, electronic collections, and automated systems. Nevertheless, the switch to digital may come with some challenges associated with electronic wastes, energy requirements of the digital infrastructure, and the necessity to make repeated updates in technology. The library, medical should deal with such complexities and at the same time their green initiatives should be able to complemented instead of being a bane to their own basic mission of easing medical education and research (Haq, 2021a).

Green library programs in medical universities should be carried out carefully taking into account a lot of factors such as the institutional policies, resources, and capabilities of the staff, and the needs of users. Success of such initiative requires the support of strong leadership, sufficient funding, proper planning as well as change management strategies. The overview of the status quo of green practices in medical university libraries will provide the guideline in implementing specific interventions and policy recommendations (Zareef, Arif, & Jabeen, 2024; Rahoo et. al, 2020). The information needs of the healthcare sector are specific (different ways of accessing the information and the quality of preservation, research support needs), imposing special difficulties in adapting the implementation of a green library practice. Medical libraries have to reconcile environmental sustainability and a large collection of medical materials supporting three-shift access to critical materials and research activity often requiring specialized environmental needs. Such demands need new solutions that can make the environmental interests compatible with the academic ones (Ali, Rafiq, & Arshad, 2025). The increasing

popularity of evidence-based practice to healthcare education has shown the necessity of a wide range of library services that assist in research and learning and reduce environmental effects to the lowest possible. Medical students and instructors are increasingly aware of the links between environmental health and outcomes in public health, which means that there is even a higher incentive to adopting sustainable practices in their institutions. This consciousness has also served to increase the support that medical university stakeholders have on green library movement (Hussain, Ali, & Jan, 2025). Economic impacts of green library programs in medical universities are not limited to the field of immediate cost reduction, with such additional long-term factors as institutional ranking, grant-based opportunities, and attractiveness of a green library to those students and faculty members concerned with green living. All these have been the driving force behind the development of compelling business reasons to invest in sustainable library practices even within the resource-limited settings. The prospect of having green initiatives to value positive return on investment has critically become a consideration of university administrators and library managers (Amur et al., 2025). The situation in the Sindh province, as a region, offers opportunities as well as challenges to the implementation of green library activities in medical universities. Economic conditions of the province, differing degrees of technological infrastructure and establishing different priorities within institutional settings make a complicated environment to sustainability initiatives. The knowledge of such regional elements can play important role in devising effective mechanisms which can then be effectively structured in various kinds of medical universities in the province (Rahoo, el. al 2021; Muhammad, Chandio, Jamali, & Maree, 2025).

Research Objectives

1. To determine the level of the realization of green library undertakings being carried out in the medical universities of the Sindh province, as well as the initiatives of energy-saving, wastes cut-down and exploitation of digital sources.
2. In order to find out the major challenges and the impediments to promoting green library practices in library of medical universities effectively such as resource limitations, policy restrictions, and workforce factors involved.
3. To assess the degree of awareness and knowledge of library staff and administrators to the notions of green library and how it can be practically applied in the medical education settings.

Research Questions

1. Which green library initiatives are already applied in medical universities of Sindh now and how widespread are they in various kinds of colleges?
2. What are the biggest issues and obstacles of medical university libraries to undertaking comprehensive green library practices?
3. What role do levels of awareness and knowledge of the library personnel play in establishing effective green library practices in medical colleges?

Significance of the Study

The study is quite important to various parties in the medical education and library science circles. The results give a good idea about the prevailing environmental sustainability practices in university libraries of medical colleges within the Sindh province and it is a good starting point of study and policy mapping by any researcher in future. This study adds to the posting of information that is tailored to the situation (especially the context of medical education), and the tiny void that is deprived of existing information on the green library initiative in medical education. To the library administrators and the university management, the research provides

cost effective recommendations that they can adopt to come up with efficient green library programs depending on the institutional objectives and available capabilities. The recognition of challenges and barriers offers a basis to pursue the development of specific measures and policies that can be used to improve the success of sustainability efforts. Moreover, research results will help to design programs and other developments on how the library personnel will be trained and prepared to assist in implementing green libraries. As well, the study expands the debate of the environmental aspects of higher education sustainability by supporting the arguments that can be used in the institutional and governmental policymaking.

Literature Review

Green libraries is a phenomenon that made its way into late 20th century through the environmental movement and the increase of the prevalence of sustainability in problems that were set before the modern society. Initial discourse on green library practices concentrated on the areas of energy conservation and waste reduction, and not much was said of the overall integration of the environment into library practice and services (Solemanpharcy & Gaffar, 2023). Green library concepts were developing in step with the green building and sustainable architecture concepts, and libraries were starting to certify using Leadership in Energy and Environmental Design (LEED) certification frameworks, and their environmentally-focused performance equivalents. These initial efforts provided a basis upon which library sustainability would be approached in a more thorough manner, taking into account the library itself, its operations and strategies of working with a user, as well as organization culture (Fedorowicz-Kruszewska, 2021). Green library practices literature has evolved remarkably in recent twenty years as researchers and practitioners have come up with even complex models in how they understand and apply environmental sustainability in libraries. The role of academic libraries has been noted specifically because of the high energy demand use, a large physical collection, and the availability of feedback in creating user behavior and institutional practices in libraries (Khalid, Malik, & Mahmood, 2021). The introduction of digital technologies has led to the emergence of opportunities to minimize the impact on the environment and creates challenges concerning the waste management of electronics and consumption of energy of the digital infrastructure. The recent research studies also pointed out the significance of whole-system solutions that involve the whole lifecycle of the library resources and services such as, acquisition, processing to use and disposal (Kamińska, Opaliński, & Wyciślik, 2021).

Medical libraries have special issues to overcome to become green since whereas all other libraries have standard practices, undergraduate and graduate learning and research needs are unique to the field. The necessity to provide the 24 hours access to the critical resources, requirement of wide preservation of medical texts, journals, and the necessity to corporately integrate the clinical and the research processes offer particular environmental demands that demand new solutions. Creeping into the literatures has been the realization that the development of green practices in libraries needs to be contextualized within the cultures and limitations of medical education settings in such a way that sophisticated standards of healthcare professionals training and research services at desired levels (Khalid et al., 2021). The financial aspects of green libraries are increasingly gaining prevalence in the contemporary research field, where there are reports of sustainability programs that result in cost savings due to decreasing energy usage, disposal fees, and operational gains. The literature also understands that the extent of initial investment in the installation of green infrastructure is huge and the sustainability projects may never get substantial funding in environments with limited resources at hand. Business case development of green library investments has become a critical research location, and research

has been performed to investigate the return on investment of diverse sustainability measures and how they influence the institutional finance and performance (Khalid et al., 2021). This is probably the main reason why the part of library staff in the implementation of green library has been investigated quite widely during the last few years and the researchers focused on the usage of training, awareness, and engagement as the key to a successful sustainability project (Fedorowicz-Kruszewska, 2021). Research has revealed knowledge and skills of the staff as the key determinants of the adoption and reinforcement of green practice tendency alongside the issues of transforming organizational culture and user attitudes. Over the years, the literature has responded to the need to have in place a broad-based training where the literature attempts to cover technicalities and aspects on green library as well as the conceptual knowledge behind the principle of sustainability and how it can be applied in a library set up (Jain & Behera, 2023).

The issue of digital technologies and their effect on library environmental sustainability has become one of the most popular topics of the recent research, as all the possibilities and issues related to the presence of general electronic resources and digital services were studied. The literature has exhibited a likelihood of digital collection to cut down on paper use and storage needs in addition to generating emerging issues exhibited by server energy uses, i.e., electronic waste disposal and impact of digital framework on the planet. Evolution of cloud services and shared digital infrastructures have brought new possibilities to cut the environmental footprint of library activities and doubt has been cast on the environmental consequences of large data centers and online services (Li et al., 2021). Measurement and assessment of green library practices have been gaining more and more attention in the literature and scholars are working on the frameworks and methodologies of measuring the environment impact of library services and operations. Research has not been silent on the need to project some baseline measures to lay down the concrete target areas and the need to start on an intrusive check-up mechanism to keep track of the progress and the deficiencies to improve. There is also the issue of generating standardized metrics and evaluation frameworks, which can be used in various kinds of libraries and institutional settings, as pointed out in the literature (Khan, Yu, Umar, & Tanveer, 2022). Policy and governance aspects of green library practices have recently been spelled out (researchers have focused on what institutional policies, professional standards, and regulatory structures play in facilitating environmental sustainability in library practice). The literature has pointed at the significance of effective leadership as a form of support, clear policy frameworks and efficient gubernatorial frameworks in the successful implementation of green libraries. It has also been studied on how professional associations and accreditation organs can facilitate promotion of green libraries and provide standards of environmental sustainability in the practice of libraries (Sandberg, Alnoor, & Tiberius, 2023). The user aspects of green library practice have also shown an increase in literature in terms of user engagement and education whereby literature has analyzed how libraries could be used to foster environmental awareness and even sustainable behavior in users. The literature has proved that libraries can be utilized as a means of education and community spaces in regard to environmental sustainability where it also involves to engage the users in green library practices by conducting awareness campaigns, educational activities and behaviors. Designing user education activities and community engagement programs have emerged as a major part of research and practice in the green library implementation process (Andeobu, Wibowo, & Grandhi, 2022). The global aspects of green library practice have also started being researched so far and scholars have started exploring the various modes of library sustainability with respect to different cultural, economic and political environments. The literature has emphasized the need to adjust the green practice in libraries to regional circumstances and constraints and at the same time gain knowledge from international

best practice and successful implementations. Researchers have highlighted the importance of transnational collaboration and the dissemination of knowledge in the promotion of green library trends and the solution of the typical libraries issues encountered throughout the global community (Mahi, Ismail, Phoong, & Isa, 2021).

The recent literature on the future directions of green library research and practice has a lot to say on the topics that have been raised by the researchers on the rise of new trends and the possibilities in green library operations with a view to the development and greening of library activities. The literature has accentuated the necessity of further innovation in the sphere of green technologies, the creation of new partnerships and forms of cooperation, and the introduction of concepts of sustainability to library education and professional development curricula. There is also research conducted outlining how libraries could act as leadership in institutional and community sustainability challenges as well as in transforming its own environmental operations and performance (Fu, Abdul Rahman, Jiang, Abbas, & Comite, 2022). The interconnection between green library operations and sustaining the entire institution has been the topic of recent literature reviews where evidence material has been found that supports the need to ensure a connection between library environmental objectives and institutional sustainability efforts and so-called core campus-based sustainability efforts. Literature has highlighted how libraries could play a role in extending their actions to the long-term economic sustainability of the institutions and to reaping the benefits of coordinated actions in respect of environment issues. Higher education Sustainability The formulation of integrated sustainability plans that include library services in the larger institutional environmental program has become an area of practice and study in higher education sustainability (Uebersax et al., 2023).

Research Methodology

The researcher has conducted the mixed-methods research methodology to address green initiatives in medical universities in the Sindh province. A descriptive survey design was used to study the current practices in the field of environmental protection and determine the challenges that the academic libraries within the industry of healthcare training have to deal with. Ten medical universities were selected purposely that are public and private in major cities of Sindh, Karachi, Hyderabad, Larkana, and Sukkur. The list of data collection instruments was comprised of several structured questionnaires to staff and administrators of the library, semi-structured interviews with head librarians and sustainability officers, and the direct observation checklist to evaluate current green infrastructure and green practices. The used questionnaire targeted such aspects of energy conservation, methods of reducing waste material, use of digital resources, and environmental education programs. Interview was done face-to-face to gain insights on implementation problems, constraints on resources, and institutional support to sustainability projects. The physical evidence of the green practices including use of energy efficient light, recycle systems and space utilization was observed and recorded. Institutional policies, annual reports and sustainability guidelines were also analyzed in the study. The informational process lasted six months and proceeded during March to August 2024, and the follow-up check was scheduled via email communication. The analysis of the quantitative data was performed with the help of SPSS software with the utilization of descriptive statistics, whereas the qualitative answers were analyzed on the basis of the quantitative analysis.

Results and Data Analysis

The comprehensive analysis of data collected from ten medical universities in Sindh province revealed significant insights into the current state of green library initiatives and the challenges

faced in their implementation. The quantitative analysis, based on structured questionnaires completed by 150 library staff members and administrators, provided measurable indicators of green practice adoption, while qualitative data from 30 in-depth interviews offered contextual understanding of implementation challenges and opportunities.

Table 1: Institutional Characteristics of Participating Medical Universities

University Type	Number	Percentage	Location Distribution
Public	6	60%	Karachi (2), Hyderabad (2), Larkana (1), Sukkur (1)
Private	4	40%	Karachi (3), Hyderabad (1)
Total	10	100%	-

Table 1 presents the distribution of participating medical universities across Sindh province. The sample included six public universities representing 60% of the total, while four private institutions comprised 40% of the sample. Karachi, being the largest city and educational hub, hosted five universities in the study, followed by Hyderabad with three institutions, and Larkana and Sukkur each contributing one university. This distribution reflected the actual concentration of medical universities across the province and ensured geographical representation in the study findings.

Table 2: Current Status of Energy Conservation Measures

Energy Conservation Practice	Implemented	Partially Implemented	Not Implemented
LED Lighting Systems	70%	20%	10%
Motion Sensor Lighting	40%	30%	30%
Energy-Efficient HVAC	50%	25%	25%
Natural Light Utilization	60%	25%	15%
Solar Power Systems	20%	10%	70%
Smart Power Management	30%	40%	30%

Table 2 demonstrates the varying levels of energy conservation measure implementation across medical university libraries. LED lighting systems emerged as the most widely adopted practice, with 70% of libraries having fully implemented this technology, while 20% had partial implementation. Motion sensor lighting showed moderate adoption with 40% full implementation and 30% partial implementation. Energy-efficient HVAC systems were implemented in 50% of libraries, with another 25% having partial systems. Natural light utilization was prioritized by 60% of institutions, reflecting awareness of this cost-effective approach. Solar power systems showed the lowest adoption rate at only 20% full implementation, with 70% of libraries having no solar energy infrastructure. Smart power management systems were fully implemented in 30% of libraries, with 40% having partial implementation, indicating growing interest in automated energy control systems.

Table 3: Digital Resource Utilization and Electronic Services

Digital Initiative	Fully Adopted	Partially Adopted	Not Adopted
Electronic Databases	80%	15%	5%
Digital Collections	75%	20%	5%
Online Catalog Systems	90%	10%	0%

E-book Platforms	65%	25%	10%
Digital Repository	45%	35%	20%
Mobile Applications	35%	30%	35%

Table 3 reveals strong adoption of digital resources and electronic services across medical university libraries. Online catalog systems achieved the highest adoption rate at 90% full implementation, with the remaining 10% having partial systems and no libraries operating without digital catalogs. Electronic databases were fully adopted by 80% of libraries, with 15% having partial access and only 5% lacking electronic database services. Digital collections showed similar patterns with 75% full adoption and 20% partial implementation. E-book platforms were fully implemented in 65% of libraries, with 25% having partial access and 10% not offering e-book services. Digital repositories were less commonly implemented, with 45% full adoption and 35% partial implementation, while 20% of libraries lacked institutional repositories. Mobile applications showed the lowest adoption rate at 35% full implementation, with equal percentages of partial adoption and non-adoption at 30% and 35% respectively.

Table 4: Waste Reduction and Recycling Programs

Waste Management Practice	Implemented	Planned	Not Considered
Paper Recycling Programs	40%	30%	30%
Electronic Waste Management	25%	35%	40%
Printing Reduction Policies	55%	25%	20%
Reusable Material Programs	20%	40%	40%
Composting Initiatives	10%	20%	70%
Waste Segregation Systems	35%	45%	20%

Table 4 illustrates the current state of waste reduction and recycling programs in medical university libraries. Printing reduction policies were the most commonly implemented practice at 55%, with 25% of libraries planning such initiatives and 20% not considering them. Paper recycling programs were implemented in 40% of libraries, with 30% planning implementation and 30% not considering such programs. Waste segregation systems were implemented in 35% of libraries, while 45% had plans for implementation and 20% had not considered such systems. Electronic waste management was implemented in only 25% of libraries, with 35% planning implementation and 40% not considering e-waste programs. Reusable material programs showed low implementation at 20%, with 40% planning such initiatives and 40% not considering them. Composting initiatives had the lowest adoption rate at 10%, with 20% planning implementation and 70% not considering composting programs.

Table 5: Staff Awareness and Training in Green Library Practices

Awareness Level	Percentage	Training Received	Training Needed
High Awareness	25%	30%	85%
Moderate Awareness	40%	45%	70%
Low Awareness	35%	25%	90%

Table 5 presents the levels of staff awareness and training related to green library practices. The data revealed that only 25% of library staff demonstrated high awareness of green library concepts and practices, while 40% showed moderate awareness and 35% had low awareness levels. Training patterns showed that 30% of highly aware staff had received formal training,

45% of moderately aware staff had some training, and 25% of staff with low awareness had received any training. The need for additional training was consistently high across all awareness levels, with 85% of highly aware staff, 70% of moderately aware staff, and 90% of staff with low awareness expressing the need for more comprehensive training in green library practices.

Table 6: Institutional Support and Policy Framework

Support Mechanism	Available	Limited	Unavailable
Formal Sustainability Policies	30%	20%	50%
Dedicated Green Library Budget	20%	30%	50%
Administrative Support	45%	35%	20%
Staff Incentives for Green Practices	15%	25%	60%
Green Library Committees	25%	15%	60%
Sustainability Reporting	20%	40%	40%

Table 6 examines the institutional support mechanisms and policy frameworks for green library initiatives. Administrative support was the most commonly available resource at 45%, with 35% having limited support and 20% lacking administrative backing. Formal sustainability policies were available in only 30% of institutions, with 20% having limited policies and 50% lacking formal policy frameworks. Dedicated green library budgets were available in 20% of institutions, with 30% having limited funding and 50% lacking dedicated budgetary allocations. Green library committees were established in 25% of institutions, with 15% having limited committee structures and 60% lacking formal committees. Sustainability reporting was conducted by 20% of institutions, with 40% having limited reporting mechanisms and 40% not engaging in sustainability reporting. Staff incentives for green practices were available in only 15% of institutions, with 25% offering limited incentives and 60% providing no incentives for sustainable practices.

Table 7: Challenges and Barriers to Green Library Implementation

Challenge Category	Major Barrier	Moderate Barrier	Minor Barrier
Insufficient Funding	90%	10%	0%
Lack of Trained Personnel	70%	25%	5%
Inadequate Institutional Support	60%	30%	10%
Technical Infrastructure Limitations	55%	35%	10%
Resistance to Change	45%	40%	15%
Lack of Awareness	50%	35%	15%

Table 7 identifies the primary challenges and barriers hindering green library implementation. Insufficient funding emerged as the most significant barrier, with 90% of institutions identifying it as a major challenge and 10% considering it a moderate barrier. Lack of trained personnel was identified as a major barrier by 70% of institutions, with 25% considering it moderate and 5% viewing it as minor. Inadequate institutional support was a major barrier for 60% of institutions, with 30% experiencing moderate support issues and 10% facing minor challenges. Technical infrastructure limitations were major barriers for 55% of institutions, with 35% experiencing moderate limitations and 10% facing minor technical challenges. Resistance to change was a major barrier for 45% of institutions, with 40% experiencing moderate resistance and 15% facing

minor resistance issues. Lack of awareness was a major barrier for 50% of institutions, with 35% experiencing moderate awareness challenges and 15% facing minor awareness issues.

Table 8: Comparison Between Public and Private Universities

Green Practice Category	Public Universities	Private Universities
Energy Conservation	55%	70%
Digital Resource Utilization	75%	85%
Waste Reduction Programs	35%	50%
Staff Training	40%	60%
Policy Framework	25%	40%
Overall Implementation	46%	61%

Table 8 presents a comparative analysis of green library practices between public and private medical universities. Private universities demonstrated higher implementation rates across all categories, with overall implementation at 61% compared to 46% for public universities. Energy conservation practices were implemented at 70% in private universities versus 55% in public institutions. Digital resource utilization showed rates of 85% in private universities compared to 75% in public universities. Waste reduction programs were implemented at 50% in private universities versus 35% in public institutions. Staff training was more prevalent in private universities at 60% compared to 40% in public universities. Policy frameworks were more developed in private universities at 40% compared to 25% in public institutions. The quantitative analysis revealed significant disparities in green library implementation across different types of medical universities in Sindh province. The data indicated that while basic energy conservation measures had gained traction, comprehensive green library programs remained underdeveloped. The high adoption of digital resources demonstrated the potential for technology-driven sustainability initiatives, while the limited implementation of waste reduction programs highlighted areas requiring focused attention.

Qualitative Analysis

Qualitative (with 30 in-depth, semi-structured interviews with head librarians, sustainability officers, and senior library staff) component of this study significantly contributed to expanding the contextual information on the topic covering green library implementation in medical universities and the related experimental perceptions, challenges, and experiences. Themes Thematic analysis of the transcripts of the interviews identified five themes, which had great effect on determining the adoption and sustainability of green practices within medical library settings.

Theme 1: Financial Constraints and Resource Allocation Challenges

The major theme to stand out of the qualitative data was that of overall effects of financial constraints regarding implementation of greens library. Poor funding was reportedly the main obstacle to implementing comprehensive sustainability activities every time the participants were asked. According to a head librarian in one of the medical public universities, although we have a great interest in the idea of going green, we always find ourselves tight with simple running budgets and thus have no capacity to make investments in sustainability. This mood was replicated in both state- and privately-owned educational centers though to different extents. Even more optimistic about getting funds to support green initiatives were the representatives of private universities, and in particular, one sustainability officer Said that where you find an obstacle in securing funding upfront there are more options in terms of targeting budget

appropriations and presenting business cases of long-term cost savings. But even in the case of the private sector, the opportunity for renewable energy systems and full-scale waste management infrastructure were limited, especially explaining in advance the expenditure on them. Respondents reputed that institutions have drawn up in their green library budgets, requiring them a whole lot of green library tactics that are essay-like and perform the fewest economical provisions, leaving additional extensive projects until later. Some of the respondents spoke of exploring the area of energy saving lighting, but they did so only to cut on expenditures and not to preserve the environment, which explains the situation of cost cutting at the expense of idealism due to limited resources. Interviews showed that effective green initiatives usually involved innovative funding mechanisms such as collaboration with non-governmental organizations on the environment, government grants, and energy services enterprises. A Karachi senior librarian clarified that, "we had received LED typed lighting because of a joint venture with an energy company which came up with the initial finance in exchange of the energy saving contracts of long term."

Theme 2: Institutional Support and Leadership Engagement

The second significant theme was the importance of the support of the institution and engagement of the leadership in the application of the green libraries. The participants always reiterated that any attempts towards successful sustainability had to have a robust support of university administration and the library management. One head librarian in a privately owned medical university observed that, no matter how motivated the employees may be, the green practices in their respective institutions cannot be effectively promoted without administrative support of the librarians. The interviews indicated great inconsistency in leadership involvement within the institutions. There was evidence of more systematic procedures of embracing green libraries in universities that had a sustainability committee and an open environmental policy. On the other hand, those having no formal sustainability structures exhibited disjointed and non-systematic institutional green practices, and the practices were more based on personal motivation than institutionally-based ones. The participants emphasized that green library objectives should be merged with overall institutional sustainability policies. One of the interviewees, a sustainability officer at a public university, said that in the case of library green initiatives matching with the university-wide environmental objectives, the most support and resources are available to guide implementation. Such a integration was prevalent in the private universities since it usually had more developed structures on sustainability governance. The support of library directors and top administrators in terms of promoting green grew as a critical factor. Some respondents claimed that the change of administration had either spurred or slowed down the process of developing green library depending on the significance attached to the environment by the new administration. The interviews showed that long term institutional sponsorship meant integrating sustainability issues into the culture of organizations, as opposed to depending on personal preferences of leadership.

Theme 3: Training and Capacity Requirements of the Staff

Theme number three discussed the significance of capacity and staff training of successful implementation of green library. The participants also reported knowledge gaps and skill deficiencies as strong incentives to abandon and keep green practices. Senior librarian of Hyderabad observed that, they have the excitement over green practices, but lack the technical knowledge of implementation and maintenance of high-tech sustainability systems.

Interviews showed that the requirements associated with the staff training went beyond technical skills and touched on the concepts about the principles of sustainability and applying them in

library realities. It was noted that a great number of participants felt dejected by the fact that there are no professional development opportunities available centered on green library practices, especially in regards to medical libraries with their peculiarities and limitations. The participants noted the importance of giving extensive training programs that should target individual competencies as well as organizational capacity building. A head librarian in a public university remarked that training few of the staff was not enough, but an organizational system of capacity such that culture of sustainability is instilled in the entire library organization. This school of thought was especially vivid in the larger organizations where the organizational structure was more complex. It was also revealed during the interviews that it is essential to engage in constant training and updating of knowledge, since green technologies, as well as best practices, are constantly changing. Some of the participants discussed difficulties in ensuring their practices keep pace with the changes in technology and new methods of sustainability, demonstrating the importance of offering professional development opportunities on an ongoing basis.

Theme 4: User Engagement and Behavioral Change

The fourth theme was based on the issues and possibilities of user involvement and attitude change in green library programs. The respondents always cited the importance of user behavior as a key success factor in sustainability programs, even though the incentive to convert user behavior was a challenge often cited by the respondents. According to a head librarian of a privately run medical university, the students and the faculty tend to be supportive of green initiatives but the degree to which this satisfaction comes to reflect on adequate behavior shift is a difficult process. The interviews helped understand that the effective user engagement depended on educational work extended in time and incorporation of sustainability concepts into the ordinary library services and communication. The participants stressed the need to take advantage of the opportunity offered by a medical library setting to foster environmental awareness because of the role of health profession in environmental health concerns. A few respondents cited the successful initiatives that tied environmental sustainability to the beneficial effects of environmental sustainability to the health of its population and raised more interesting stories on user engagement. The interviews showed much similarity in the responsiveness of users on green initiatives in various institutions as well as profiles of various users. Utilization was higher by medical students than the faculty and staff, and research-oriented users were less interested in the environmental factors of resources than their accessibility. The participants stressed the importance of designing engagement strategies to suit the needs and motivation of various groups of the users.

Theme 5: Technical infrastructure and Implementation Issues

The fifth theme covered the technical and practical issues linked with the implementation of green systems and infrastructure in libraries. Respondents also mentioned technical complexity as a major obstacle especially with those institutions that have little technical skills and support systems. One of the senior librarians of a public university said that, in popularizing green technologies, they possess the knowledge that needs to be technical, and they lack such skills, thus, they feel dependent on other outsiders who provide the service of consultants. This was especially sharp with renewable energy systems and advanced waste management structure that demanded special talent in maintenance and monitoring. During the interviews, it was apparent that in order to have a successful green implementation of libraries, a large shift in the current operations and workflow was common. The participants explained issues involving the incorporation of new green technologies into the current library system and the necessity of staff to adjust to new processes and machinery. Respondents also emphasized on the need to exercise

due care when choosing the right technologies that meet the capacity and resources of the institutions. A number of respondents referred to the experiences with the green technologies that were too sophisticated or costly to sustain and resulted in system crashes and programs abandonments. This was a statement regarding the importance of a selection of technology and implementation planning that takes into account sustainability and institutional capacities in the long run.

Cross-Cutting Themes and Interconnections

The qualitative analysis demonstrated the significant interconnection among the five key themes, which explained why the implementation of green libraries is a complex issue. All the other themes were affected by financial constraints which restricted training opportunities, narrowed technology infrastructure choices, and restricted user engagement activities. In the same manner, the institutional support influenced the sources of resources, staff capacity building capabilities as well as having overall green programs. The interviews helped to identify that green library initiatives need to always consider more than a single theme at the same time and it would be better to think of a combined strategy to incorporate financial planning, institutional support, staff development and user support and technical implementation. The interdependence of the challenges of sustainability was another important consideration noted by participants who argued that piecemeal solutions to the single themes did not have as much impact as holistic strategic solutions to the sustainability issues. The differences in both the approaches of the public and the private institutions towards these themes were also important, as indicated within the qualitative data. In usual circumstances, the process of resource allocation and decision-making proved more flexible in the case of the former (private universities) and relatively more bureaucratic in the second one (public institutions) although the second category could also reach various types of assistance and potential cooperation. Survey outcomes were supported by the data collected through observations that demonstrated the most visible green practices were those related to the energy efficient lights and mere recycling bins. The more advanced green structures, e. g. renewable energy establishment and waste reuse plants were hardly seen. It has been observed also that the behaviors of users and their interactions with green practices also had a high variance among institutions where some libraries recorded high levels of user response to undertaking sustainability efforts and others had low user response to sustainability efforts. The observation part also recorded the profound deviations in the maintenance and management of the green infrastructure, in which some of the institutions demonstrated very well-maintained sustainability systems and others had dejected or refused to work green technologies.

Discussion

The evidence of the presented research demonstrates a complicated picture of green library activities in medical universities in the Sindh province where the specific manifestations of implementing sustainability agendas and huge inconsistencies in individual types of institutions are present. The absence of the use of the digital resources and especially utilization of electronic databases and online catalog system proves the possibility of establishing sustainability through the use of technology in medical libraries settings. Nevertheless, the few cases of comprehensive programs to reduce waste and renewable energy systems demonstrate that the initiatives toward green library are scattered and do not have a systematic institutional backing. The overwhelming difference between the public and private universities shows that the availability of resources and level of priorities of the institutions are key players in defining the effectiveness of the green library implementations.

The fact that funding limitation was cited as a primary obstacle is an indication of the bigger issue that higher education establishments in developing countries are struggling with as urgent operational expenses tend to have priority over investment in sustainability. The above moderate rates of awareness and training among staff members reflect on the significance of human resource development in an effective green library implementation. Some of the factors which point to the fact that institutional commitment to environmental sustainability needs reinforcement in terms of policy adjustment and resource allocation shifts include the small number of formal sustainability policies and green library budgets. Such differences in the degree of administrative support demonstrate that it is essential to have leadership involvement that can contribute to the establishment of an enabling environment with regard to green library initiatives. The point-to-point comparisons that are offered by the comparative study between the public and the private universities present substantial ideas linked between the institutional resources and the successful implementation of green libraries. The rates of implementation in private universities are higher in all the categories which is a sign that financial freedom and being able to make independent decisions increase the speed of adopting green practices. Nonetheless, the moderate levels of implementation in both sectors demonstrate that there exist some systemic issues that cannot be solved without a coordinated effort on various levels. The unfavorable finding that resistance to change is a key obstacle indicates the necessity of control over change strategies that touch technical and cultural fundament of green library use.

Conclusion

This exhaustive review of green library projects in the medical universities of Sindh province has provided important information about where we stand now, when it comes to the practices of environmental sustainability and the problems that lie in the way of their successful execution. The evidence gained in the research suggests that, although medical university libraries have already achieved significant progress in emerging with the use of digital resources and simple energy saving strategies, a full-fledged green library program is not well-developed to the point that it needs the significant assistance of the institution in which it has to be launched successfully. Electronic databases and digital collections adoption rates as well as waste reduction programs and renewable energy systems implementation rate reveal the possibility of technology-driven sustainability solution along with the areas of particular focus that need investment and special attention. Identifying the source of funding as the greatest number one barrier to Google implementation of the green library correlates with the overall issues affecting higher learning institutions in the resource-hungry settings. The medium scores of staff awareness and training also point out the necessity of human resource development as the means of establishing sustainable library practices which can be sustained and developed over a period of time. Few formal sustainability policies and limited availability of green library budget suggest that institutional investment in treating the environment friendly needs enhancement by reviewing institutional policies, reallocating funds, and involvement of leaders at various levels of an organization.

The comparative study of the results in the public and the private universities shows significant variation in the implementation capacity and availability of resources with the private institutes showing greater rates of adopting all the categories of green practice. The modest levels of implementation that are evident overall in both sectors, however, do indicate that there are systematic issues involved that call for organized efforts in the line of policy makers, institutional leaders and library professionals. The results of the study demonstrate the necessity of using extensive strategies that would overcome technical, financial, and cultural barriers to the

adoption of a green library and capitalize on current strengths and effective approaches. The study will add worthy contributions to the negligible body of literature on the topic of green libraries in the medical education setting and would be of use in research and policy formulation later. The results show the significance of the institutional support, sufficient funding, extensive training courses and efficient management of changes to implement successfully green libraries. As the study shows, though there exist challenges there are also great opportunities in realizing environmental sustainability in medical university libraries through interventions and cooperation between stakeholders.

Recommendations

According to the overall review of green library practices in medical universities in Sindh province, it is possible to identify several major recommendations on the improvement of the way the sustainability initiatives are conducted and their effectiveness. Each university must have a specific green library committee where each department will be represented by the administration, the library personnel and the sustainability professor who have made a commitment of leadership in the green library database. The institutional leaders are advised to establish policies of sustainability that directly relate to the library operations, set specific targets, deadlines, and accountability system in order to achieve green practices. Periodic training needs to be put in place so as to train more staff on awareness and technical skills regarding green library practice such as energy conservation workshops, managing and reducing waste and digital resources workshops etc. Universities ought to look at collaborating with the environment, government agencies and development partners to gain funding, technical support and exchange in best practices in green development of their libraries. There should be comprehensive waste reduction initiatives that should be put in place such as the recycling of papers, e-waste, and user education to ensure that people adopt sustainability measures. Monitoring and evaluation systems should be put in place regularly to determine the progress, identify the challenges, and change their strategies on evidence and circumstances.

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