IJCSE
ISSN: 2347-2693 (E)

Research Article

Evaluating The Digital Performance and Accessibility of IIT Library Websites Using Google Lighthouse

Vikrant Dubey[1]*, Shilpi Verma[2]

[1,2]Dept. of Library and Information Science, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebareli Road, Lucknow, Uttar Pradesh, India

Corresponding Author: ✉

Abstract: This study presents a comprehensive performance analysis of the library websites of 23 Indian Institutes of Technology (IITs) using the Lighthouse tool. IIT libraries are essential information hubs that support the academic and research needs of students, faculty, and external researchers. To assess the digital performance of these websites, Lighthouse, a popular open-source tool by Google, was employed to evaluate key metrics such as performance, accessibility, best practices, and SEO. The analysis revealed significant variation in the quality of IIT library websites, with top performers like IIT Indore and IIT Mandi excelling in performance and accessibility. At the same time, IIT Tirupati and IIT (BHU) Varanasi lagged behind, especially in terms of loading speed and adherence to best practices. The study highlights areas for improvement, such as optimizing resource management, enhancing accessibility for users with disabilities, and improving search engine optimization (SEO) to increase discoverability. Actionable recommendations help IIT libraries improve their digital presence, ensuring a more efficient, accessible, and user-friendly user experience.

Keywords: IIT Libraries, Google Lighthouse, Web Performance, Accessibility, SEO, Best Practices, Digital Libraries, Website Analysis.

1. Introduction

In an era where libraries are rapidly evolving into digital information hubs, the efficiency and performance of library websites are critical. The IITs (Indian Institutes of Technology) are premier educational institutions in India, and their libraries serve not only students and faculty but also external researchers. This research focuses on the performance analysis of these libraries' websites, using the Lighthouse tool to understand how well they meet modern web standards and user expectations.

Lighthouse is a popular open-source tool provided by Google that helps evaluate websites based on five main categories: Performance, Accessibility, Best Practices, Search Engine Optimization (SEO), and Progressive Web App (PWA) compliance. Through this study, we aim to identify key areas where IIT library websites can improve and optimize their digital presence.

2. Related Work

In recent years, several studies have assessed the accessibility of university websites, underscoring the importance of enhancing accessibility to facilitate effective interaction with stakeholders with disabilities, and sometimes, websites have not responded adequately. It may create a difficult situation for users to get information on time.

Alhadreti [1] evaluated the state of accessibility, performance, and engagement of the higher education institute of Saudi Arabia. They used different tools for his study, namely AChecker, WAVE, Speed page insights, and similar web. The study evaluated 58 higher education web pages from both the public and private sectors. The result shows that only 8% of websites fully conform to the web accessibility guidelines 2.0. They also concluded that 95% of websites have poor performance and need improvement, but 60% have a good bounce rate.

University websites are becoming increasingly vital, representing institutions' online presence, reputation, and user accessibility. Research highlights the need for well-designed, high-performing websites to enhance user experience and institutional credibility. Despite this importance, there has been limited focus on evaluating the web performance of Malaysian university websites. Studies addressing web performance often utilize performance metrics, such as those

from Google Lighthouse, to assess loading speed, interactivity, and accessibility. In this context, Lehat et al. [2] applied an experimental approach using Google Lighthouse metrics to measure and improve web performance, focusing on design and content factors that impact usability. Their study identified improvements that were aligned with Web Content Accessibility Guidelines (WCAG) and the Web Performance Index (WPI) to enhance user experience and accessibility for Malaysian universities.

In their study, Ogbuju, Ayodeji, and Azeez [3] examine the performance and accessibility of websites for 49 accredited federal universities across Nigeria, addressing the growing need for effective digital educational resources as Nigeria's tertiary institutions expand. Using Google Lighthouse and Core Web Vitals metrics, they assessed website attributes such as performance, accessibility, best practices, and SEO. The findings reveal substantial gaps in meeting user experience standards, with only 1, 15, 3, and 5 universities achieving over 90% in performance, accessibility, best practices, and SEO, respectively. This outcome underscores the need for significant enhancements to optimize user satisfaction and digital engagement in Nigeria's educational web infrastructure.

Sumedrea et al. [4] conducted a Study on the management of page loading speeds. The research data was analyzed with the help of Google PSI, which is able to test the loading times of the academic site's pages and QS 2021 ranking for European universities so that the university takes care of the issues and increases their digital performance. It can improve candidate experiences and achieve sustainable development.

Giannakoulopoulos [5] investigated how the university's commitment to academic excellence was linked to the quality of its online presence. They select the top 100 universities in the Academic Ranking of World Universities (ARWU) Shanghai list. Various tools were tested to measure each website and produce a ranking, SEO performance ranking, and combined overall web ranking. The research findings suggest that universities prioritize the quality of their websites, while SEO utilization receives comparatively less attention, highlighting a potential area for improvement.

Sahoo et al. [6] investigated and analyzed content and navigated the content of 18 IITs. He chose the online survey method to collect data from the IIT website and prepared a 100 Checklist. Then, he found that 18 Library websites did not fulfill the criteria developed for studies. He found that IIT Delhi ranked 1 on his checklist, followed by IIT Bombay and IIT Bhubaneswar. He suggests that each IIT should develop its library website with a proper domain name and provide recommendations on multiple languages of the website.

Verkijika and De Wet [7] evaluated 26 South African university websites and found that all had accessibility issues, broken links, and poor mobile responsiveness. None of the websites complied with WCAG 2.0 standards.

A study conducted in 2018 revealed that people tend to explore more from mobile devices but tend to read more details on the desktop [8]. Consequently, the latest users of academic websites (the "digital natives") expect to access specific information as quickly as possible, valuing not only the content of the sites but also the time required to find the needed information [9].

Menzi-Cetin et al. [10] evaluated the usability of a state university website for visually impaired students. The five visually impaired students who participated were asked to think aloud when performing 11 tasks involving their university's main page, the library, and departmental web pages using screen readers. At the same time, the researchers took notes on an observation form. The most important result was that finding exam dates on the calendar was the most challenging task. Accessing the course schedule web page and library web pages required longer than other tasks, while accessing the main page was always the most quickly finished task.

3. Objectives Of The Study

Objectives of the study are as follows:
1. To assess the overall performance of IIT library websites using Lighthouse.
2. To evaluate accessibility metrics and identify any barriers to users with disabilities.
3. To examine SEO performance and recommend ways to enhance discoverability of library resources.
4. To analyze best practices compliance and suggest improvements.
5. To provide actionable recommendations for IIT libraries to enhance user experience.

4. Methodology

A. Selection of Websites
The study focuses on the library websites of all 23 IITs in India. Each website was selected based on its official web presence, and the URLs were collected directly from the official IIT Library website mentioned in Table 1.

B. Data Collection Tool: Lighthouse
Google Lighthouse, an open-source, automated tool by Google, was employed to conduct the web performance audit. Lighthouse was used via the Chrome DevTools (Inspect → Lighthouse) and additional verification was performed using the Mobile-Friendly Test to ensure consistency in evaluation. Mobile-friendly test to analyze each IIT library website every day from October 01, 2024, to October 10, 2024. Each IIT library website was tested once per day, and the recorded values were averaged to ensure reliability. The audits were conducted using the desktop mode in Lighthouse under consistent network conditions. Then, an average of each observation in whole numbers was recorded. The tool provides insights into four categories:
1. **Performance**: Measures loading speed, interactivity, and visual stability (Factors considered: First Contentful Paint

(FCP), Largest Contentful Paint (LCP), Cumulative Layout Shift (CLS))

2. **Accessibility**: Assesses how well the website is usable by individuals with disabilities (Factors considered: Proper text contrast, screen-reader compatibility, alternative text for images, keyboard navigation).

3. **Best Practices**: Check adherence to best coding practices for a secure and modern web experience (Factors considered: Secure connection (HTTPS), proper image and video encoding, absence of outdated JavaScript libraries).

4. **SEO**: Evaluate the website's search engine optimization (Factors considered: Meta descriptions, heading structures, structured data compliance).

5. **Mobile-Friendly Test**: Ensures the website displays and functions well on mobile devices (Factors considered: Adaptive screen layouts, touch elements spacing, viewport configuration).

Each website was assigned a Lighthouse score out of 100 for each metric. The average scores were calculated to identify high and low performers across all categories. Performance trends and outliers were further analyzed to highlight key areas for improvement.

This methodology ensures a systematic, objective, and reproducible evaluation of the IIT library websites, providing valuable insights into their digital performance and areas needing optimization.

Table 1: List of Library websites

S. No.	Name of IIT	Website	Year of establishment
1	IIT Gandhi Nagar	https://library.iitgn.ac.in/	2008
2	IIT Bhubaneshwar	https://library.iitbbs.ac.in/	2008
3	IIT Madras	https://cenlib.iitm.ac.in/	1959
4	IIT Guwahati	https://www.iitg.ac.in/lib/	1994
5	IIT Indore	https://library.iiti.ac.in/	2009
6	IIT Kanpur	https://pkklib.iitk.ac.in/	1959
7	IIT Jodhpur	https://library.iitj.ac.in/	2008
8	IIT Kharagpur	https://library.iitkgp.ac.in/	1951
9	IIT Hyderabad	https://library.iith.ac.in/	2008
10	IIT Mumbai	https://www.library.iitb.ac.in/	1952
11	IIT Patna	https://library.iitp.ac.in/	2008
12	IIT Delhi	https://library.iitd.ac.in/	2008
13	IIT Ropar	https://www.iitrpr.ac.in/library/	2008
14	IIT Mandi	https://library.iitmandi.ac.in/	2009
15	IIT Roorkee	https://mgcl.iitr.ac.in/	1847
16	IIT (Banaras Hindu University) Varanasi	https://www.iitbhu.ac.in/cf/lib	1919
17	IIT Jammu	https://www.iitjammu.ac.in/library	2016
18	IIT Palakkad	https://iitpkd.ac.in/library	2015
19	IIT Tirupati	https://iittp.ac.in/CentralLibr	2015
20	IIT Goa	https://iitgoa.ac.in/central-library-of-iit-goa/	2016
21	IIT Bhilai	https://www.iitbhilai.ac.in/index.php?pid=library_service	2016
22	IIT Dharwad	https://old.iitdh.ac.in/library.php	2016
23	IIT(Indian School of Mines), Dhanbad	https://library.iitism.ac.in/	1926

5. Analysis And Interpretation Of Data

The data were compiled and analyzed once the Lighthouse audit was performed for each website. The study focused on average scores across the five categories and outliers that performed exceptionally well or poorly in specific areas.
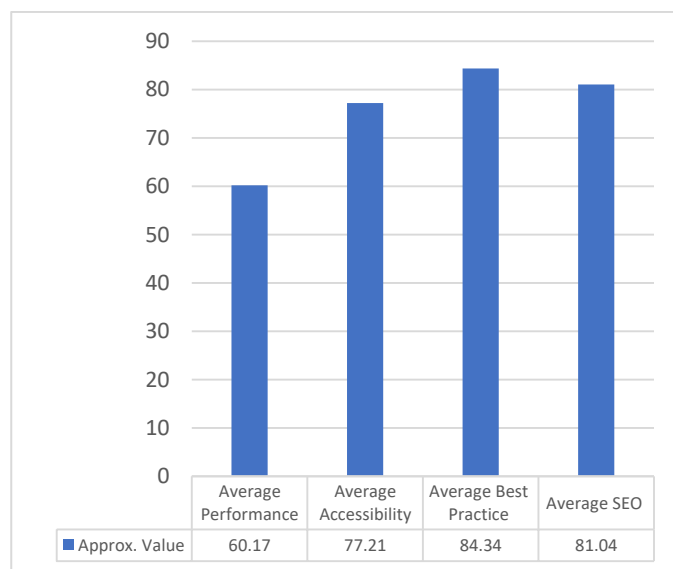

	Average Performance	Average Accessibility	Average Best Practice	Average SEO
■ Approx. Value	60.17	77.21	84.34	81.04

Figure 1: Average Scores against various categories

A. Performance

- **Top Performers**: IIT Indore (93), IIT Mandi (87), and IIT Ropar (85) lead in performance. These websites have been optimized for faster loading, efficient use of resources, and responsiveness.

- **Lowest Performers**: IIT Tirupati (12) and IIT (BHU) Varanasi (25) show significant room for improvement, indicating slow load times, inefficient resource handling, or poor mobile optimization.

Table 2: Performance score of IITs

S. No.	Name of IIT	Performance
1	IIT Indore	93
2	IIT Mandi	87
3	IIT Ropar	85
4	IIT Kharagpur	81
5	IIT Bhubaneshwar	80
6	IIT Dharwad	76
7	IIT Kanpur	70
8	IIT Bhilai	68
9	IIT (Indian School of Mines), Dhanbad	68

10	IIT Hyderabad	67
11	IIT Jodhpur	62
12	IIT Mumbai	62
13	IIT Roorkee	57
14	IIT Madras	55
15	IIT Palakkad	55
16	IIT Goa	54
17	IIT Delhi	53
18	IIT Guwahati	50
19	IIT Gandhi Nagar	48
20	IIT Patna	48
21	IIT Jammu	28
22	IIT (Banaras Hindu University) Varanasi	25
23	IIT Tirupati	12

B. Accessibility

- **Top Performers**: IIT Goa (100), IIT Kharagpur (93), and IIT Mumbai (92) score the highest in accessibility, meaning they are more likely to be compliant with accessibility standards, making the content available to a broader audience, including those with disabilities.
- **Lowest Performers**: IIT Roorkee (45) and IIT Ropar (65) show relatively low scores, highlighting areas where improvements can be made to accommodate all users, such as better keyboard navigation and contrast improvements.

Table 3: Accessibility Score of IITs

S. No.	Name of IIT	Accessibility
1.	IIT Goa	100
2.	IIT Kharagpur	93
3.	IIT Mumbai	92
4.	IIT Madras	90
5.	IIT Indore	87
6.	IIT Bhubaneshwar	85
7.	IIT Patna	83
8.	IIT Mandi	78
9.	IIT Jodhpur	78
10.	IIT Dharwad	77
11.	IIT Delhi	77
12.	IIT Tirupati	77
13.	IIT Hyderabad	75
14.	IIT Kanpur	74
15.	IIT (Indian School of Mines), Dhanbad	74
16.	IIT Palakkad	74
17.	IIT Gandhi Nagar	73
18.	IIT (Banaras Hindu University) Varanasi	72
19.	IIT Guwahati	71
20.	IIT Bhilai	68
21.	IIT Jammu	68
22.	IIT Ropar	65
23.	IIT Roorkee	45

C. Best Practices

- **Top Performers**: IIT Mandi (100) and IIT Palakkad (100) exhibit the best adherence to web development best practices. These websites follow coding standards that ensure the sites are secure, well-maintained, and use modern technologies.

- **Lowest Performers**: IIT Ropar (39) and IIT Bhubaneshwar (54) show room for improvement, suggesting potential issues with security, outdated libraries, or unoptimized resources.

Table 4: Best Practices score of IITs

S. No.	Name of IIT	Best Practices
1.	IIT Mandi	100
2.	IIT Palakkad	100
3.	IIT Mumbai	96
4.	IIT Indore	96
5.	IIT Tirupati	96
6.	IIT Hyderabad	96
7.	IIT Kanpur	96
8.	IIT Goa	93
9.	IIT Patna	93
10.	IIT Dharwad	93
11.	IIT (Indian School of Mines), Dhanbad	93
12.	IIT Delhi	89
13.	IIT (Banaras Hindu University) Varanasi	89
14.	IIT Guwahati	89
15.	IIT Bhilai	89
16.	IIT Jodhpur	86
17.	IIT Gandhi Nagar	79
18.	IIT Kharagpur	75
19.	IIT Madras	71
20.	IIT Jammu	71
21.	IIT Roorkee	57
22.	IIT Bhubaneshwar	54
23.	IIT Ropar	39

D. SEO

- **Top Performers**: IIT Madras (100) and IIT Indore (92), IIT Kanpur (92), IIT Patna (92), and IIT Goa (92) have excellent SEO scores, meaning their content is easily discoverable through search engines, which is crucial for increasing visibility and access to library resources.
- **Lowest Performers**: IIT Kharagpur (42) and IIT Roorkee (73) rank low in SEO, which suggests they may be missing key elements like meta descriptions, structured data, or proper heading tags, limiting their online discoverability.

Table 5: SEO score of IITs

S. No.	Name of IIT	SEO
1.	IIT Mandi	75
2.	IIT Palakkad	83
3.	IIT Mumbai	85
4.	IIT Indore	92
5.	IIT Tirupati	83
6.	IIT Hyderabad	69
7.	IIT Kanpur	92
8.	IIT Goa	92
9.	IIT Patna	92
10.	IIT Dharwad	75
11.	IIT (Indian School of Mines), Dhanbad	82
12.	IIT Delhi	77
13.	IIT (Banaras Hindu University) Varanasi	85
14.	IIT Guwahati	82
15.	IIT Bhilai	82

16.	IIT Jodhpur	82
17.	IIT Gandhi Nagar	82
18.	IIT Kharagpur	42
19.	IIT Madras	100
20.	IIT Jammu	75
21.	IIT Roorkee	73
22.	IIT Bhubaneshwar	91
23.	IIT Ropar	73

E. Mobile-Friendly Test

The Mobile Friendly Test (MFT) scores range from 11 to 90 across the 23 IIT libraries, with higher scores indicating better mobile compatibility. The highest score of 90 belongs to IIT Indore, while the lowest score of 11 is seen in IIT (BHU) Varanasi. The MFT scores are distributed across a wide range, highlighting a disparity in the mobile friendliness of IIT library websites.

- **Top-Performing IITs**: IIT Indore (90), IIT (ISM) Dhanbad (62), IIT Mumbai (59) had excellent Mobile friendly test score. Data shows that only IIT Indore had much more compatible with highest score as compared to others.
- **Low-Performing IITs**: IIT (Banaras Hindu University) Varanasi (11) and IIT Tirupati (13). The scores generally reflect that only a few IIT library websites are optimized for mobile use, while the majority have room for improvement in mobile accessibility and usability.

Table 6: Mobile Friendly Tests of IITs

S. No.	Name of IIT	Mobile Friendly Test
1.	IIT Indore	90
2.	IIT (Indian School of Mines), Dhanbad	62
3.	IIT Mumbai	59
4.	IIT Bhilai	58
5.	IIT Kharagpur	58
6.	IIT Madras	56
7.	IIT Bhubaneshwar	55
8.	IIT Mandi	55
9.	IIT Ropar	55
10.	IIT Dharwad	54
11.	IIT Roorkee	54
12.	IIT Goa	49
13.	IIT Hyderabad	41
14.	IIT Patna	40
15.	IIT Kanpur	37
16.	IIT Gandhi Nagar	32
17.	IIT Delhi	30
18.	IIT Guwahati	30
19.	IIT Palakkad	27
20.	IIT Jammu	20
21.	IIT Jodhpur	14
22.	IIT Tirupati	13
23.	IIT (Banaras Hindu University) Varanasi	11

F. General Observations

- **Consistently High Performers**: IIT Indore, IIT Hyderabad, IIT Kanpur, IIT Mandi, and IIT Bhilai generally perform well across all categories, indicating well-maintained websites.
- **Inconsistent Performers**: Some websites show disparities between different categories. For instance, IIT Kharagpur scores high in accessibility but low in SEO, while IIT Bhubaneshwar performs well in performance and SEO but lacks best practices.
- **Need for Improvements**: IIT Tirupati, IIT Jammu, and IIT (BHU) Varanasi show lower overall performance, especially regarding website speed, mobile friendly test and best practices, suggesting they may benefit from significant optimization efforts.

6. Findings

The analysis of IIT library websites using the Lighthouse tool reveals varying performance levels, accessibility, adherence to best practices, and SEO optimization. Performance scores ranged widely across the 23 IIT library websites, with IIT Indore (93), IIT Mandi (87), and IIT Ropar (85) demonstrating the best results. These top-performing websites are optimized for fast load times, responsiveness, and efficient resource usage. However, certain websites, such as IIT Tirupati (12) and IIT (BHU) Varanasi (25), have low-performance scores, indicating slow loading times and inefficient resource handling, requiring significant improvements.

Accessibility scores also varied, with IIT Goa (100), IIT Kharagpur (93), and IIT Mumbai (92) leading the way. These websites ensure accessibility for all users, including those with disabilities, by providing features like proper contrast and keyboard navigation. Conversely, IIT Roorkee (45) and IIT Ropar(65) have relatively low accessibility scores, highlighting the need for improvements in inclusivity, such as adding alt text for images and enhancing color contrast.

Regarding best practices, IIT Mandi (100) and IIT Palakkad (100) adhered well to modern web development standards, ensuring secure, well-maintained, and up-to-date websites. On the other hand, IIT Ropar (39) and IIT Bhubaneshwar (54) scored lower, suggesting security vulnerabilities and outdated libraries that need attention. SEO performance was generally strong, with IIT Madras (100) and IIT Indore (92), IIT Kanpur (92), IIT Patna (92), and IIT Goa (92) excelling in discoverability through search engines. At the same time, IIT Kharagpur (42) lagged, indicating poor optimization that could limit the visibility of its digital resources.

The mobile-friendly test (MFT) scores for IIT library websites vary widely, with scores ranging from 11 to 90. IIT Indore leads with a high score of 90, demonstrating a strong commitment to mobile accessibility, while IIT (BHU) Varanasi scores the lowest at 11, indicating significant challenges for mobile users. Only three IITs—IIT Indore (90), IIT (ISM) Dhanbad (62), and IIT Mumbai (59)—achieve scores above 50, suggesting that these institutions have made efforts to optimize their library websites for mobile use. The remaining IITs, including IIT Goa (49), IIT Hyderabad (41),

and IIT Kanpur (37), fall below this threshold, revealing that mobile accessibility is limited across most of the library websites. The disparity in MFT scores highlights a lack of standardization in mobile optimization across IIT libraries. Many scores cluster below 50, with more than half of the IIT libraries scoring between 20 and 50. This gap suggests that while some IIT libraries may prioritize mobile users, many others have room for improvement. Such variations could stem from different levels of investment in web design resources or focus on mobile accessibility standards. For instance, while IIT Ropar, IIT Dharwad, and IIT Roorkee all scored around 54–55, several others, such as IIT Patna (40), IIT Delhi (30), IIT Guwahati (30), and IIT Palakkad (27), fall significantly lower. These results indicate that users of most IIT library websites may experience inconsistent accessibility and usability on mobile devices, potentially leading to lower engagement among mobile users.

7. Discussion

The analysis of IIT library websites using Lighthouse highlights several critical aspects of their digital performance across metrics such as performance, accessibility, best practices, and SEO. The data reveals a wide range of results, with some websites excelling in specific categories while others struggle in areas that are crucial for providing a seamless user experience. It was clear that the average performance of 12 IITs is above the average score, where IIT Indore Rank 1 has a score of 93, followed by IIT Mandi (87) and IIT Ropar with 85. The average Accessibility of All IITs was found to be 77.21, above which only 9 IITs were found in which IIT Goa scored 100 and got Rank 1, followed by IIT Kharagpur (93) and IIT Mumbai (92). The average score of SEOs was found to be 81.04, above which only 15 IITs scored. IIT Madras got Rank 1 with a score of 100, followed by IIT Indore, IIT Kanpur, IIT Patna, and IIT Goa, scoring 92.

A. Performance Issues
Many IIT library websites show suboptimal performance scores, with only a few, such as IIT Indore (93) and IIT Mandi (87), performing exceptionally well. These websites load quickly, utilize efficient caching mechanisms, and ensure minimal delays in page interaction. However, a majority of websites, including IIT Tirupati (12) and IIT (BHU) Varanasi (25), demonstrate serious performance bottlenecks. Slow loading times, unoptimized images, and excessive use of JavaScript likely contribute to these low scores. In today's digital age, fast-loading websites are essential to keep users engaged and reduce bounce rates. Hence, improving the load speed and responsiveness of these websites should be a priority.

B. Accessibility Gaps
Accessibility is crucial, particularly in academic institutions where diverse user groups, including individuals with disabilities, need access to digital resources. The variation in accessibility scores is significant, with IIT Goa (100) and IIT Kharagpur (100) leading the way by providing accessible and inclusive content. However, websites like IIT Roorkee (45) and IIT Ropar (65) reflect accessibility challenges. Common

problems include poor color contrast, lack of alternative image text, and non-compliance with keyboard navigability standards. Enhancing accessibility will ensure all users can interact effectively with the website content regardless of their abilities.

C. Best Practices Compliance
The best practices metric is essential for ensuring that websites are built securely, maintainable, and align with modern web development standards. While many websites, such as IIT Mandi (100) and IIT Palakkad (100), follow these practices diligently, others, like IIT Ropar (39), fall short. Low scores in best practices suggest using outdated libraries or insecure code elements, which could leave these websites vulnerable to security threats and reduce their long-term sustainability.

D. SEO Optimization
The SEO scores reveal that most IIT library websites have a good foundation for discoverability, with sites like IIT Madras (100) and IIT Indore (92) , IIT Kanpur (92), IIT Patna (92), and IIT Goa (92) demonstrating strong optimization. However, some websites, such as IIT Kharagpur (42), show poor SEO practices, potentially limiting their visibility on search engines. In a world where users often turn to search engines for discovering resources, poor SEO can lead to a loss of potential visitors and reduced engagement with the library's digital assets.

E. Mobile-Friendly Test
The analysis shows a wide gap in mobile accessibility across IIT library websites, with low mobile-friendly scores often due to outdated design, limited mobile responsiveness, or lack of performance testing. As institutions of high repute, IITs need accessible digital resources to support an inclusive academic environment, especially since low scores may hinder effective mobile interaction with library resources. In contrast, libraries at IIT Indore and IIT (ISM) Dhanbad set examples of strong mobile compatibility, demonstrating that with proper design and technological investment, high mobile usability is achievable. By adopting best practices from these higher-scoring libraries, IITs with lower scores could significantly improve mobile accessibility, better serving today's mobile-first student and researcher needs.

8. Conclusion

The performance analysis of IIT library websites using Lighthouse reveals strengths and improvement areas across key metrics. While certain websites, such as those of IIT Indore and IIT Mandi, perform well in categories like performance and accessibility, others, including IIT Tirupati and IIT (BHU) Varanasi, demonstrate a need for substantial optimization efforts, especially in terms of speed and resource management. Accessibility scores also vary widely, underscoring the importance of making digital resources accessible to all users, including individuals with disabilities. The disparity in best practices and SEO scores highlights the need for some websites to adopt more modern coding standards and optimize their content for search engines. IIT

libraries can enhance their digital infrastructure by addressing these issues, making their resources more accessible, secure, and discoverable.

Recommendations
Based on the analysis of IIT library websites, several key recommendations can be implemented to improve their overall performance and user experience. Following are the recommendations based on the four key factors:

1. **For Performance**: Websites with low-performance scores, like IIT Tirupati and IIT (BHU) Varanasi, should consider compressing images, deferring JavaScript, and leveraging browser caching to improve speed.
2. **For Accessibility**: Sites with low accessibility scores, such as IIT Roorkee and IIT (BHU) Varanasi, should enhance text contrast, implement better keyboard navigability, and provide alternative text for images.
3. **For Best Practices**: IIT Ropar and IIT Bhubaneshwar should prioritize updating libraries, fixing security vulnerabilities, and adhering to modern coding standards.
4. **For SEO**: IIT Kharagpur should focus on adding meta tags, improving header structures, and ensuring proper use of schema markup to improve search engine visibility.
5. **For Mobile-Friendly Test**: To improve mobile-friendliness, IIT libraries should implement responsive design frameworks to ensure websites adjust seamlessly across screen sizes. Regular mobile usability testing can help identify and fix navigation and loading issues specific to mobile users. Optimizing page load speeds by compressing images and minimizing code will further enhance mobile accessibility. Additionally, establishing a unified mobile optimization policy across IITs will promote consistency, ensuring that all library websites provide a user-friendly experience for students and researchers accessing resources on mobile devices.

By following these recommendations, IIT libraries can offer a faster, more accessible, secure, and discoverable digital experience for their users.

Future Scope of the Study
This study provides a foundational assessment of IIT library websites, but several areas warrant further research. Future studies can explore:

1. User Experience Analysis: Conducting user surveys and usability testing to understand how students and researchers interact with these websites.

2. Comparative Studies: Expanding the analysis to include other Indian universities or international institutions for benchmarking best practices.

3. Longitudinal Performance Tracking: Monitoring the improvements or changes in IIT library website performance over time.

4. Advanced Web Technologies: Examining the adoption of AI-based chatbots, virtual assistants, and personalized recommendation systems in digital library platforms.

5. Security and Data Privacy: Assessing the security measures implemented on these websites to protect user data and prevent cyber threats.

Conflict of Interest
All authors declare no conflict of Interest

Author's Contribution
Mr. Vikrant Dubey: Writing, Structuring, Methodology & Conceptualization.
Prof. Shilpi Verma: Reviewing & Conceptualization.

References

[1] O. Alhadreti, "Accessibility, performance and engagement evaluation of Saudi higher education websites: A comparative study of state and private institutions", *Universal Access in the Information Society*, Vol.**23**, No.**4**, pp.**1671–1688, 2024.**

[2] M. L. Lehat, N. F. Abu Bakar, A. A. Jamil, C. M. N. Mohd Shafee, P. Shamala, and S. Rosnan, "Assessing web performance of Malaysian university website", *2023 IEEE 8th International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, India, pp.**1–5, 2023.**

[3] E. Ogbuju, B. Ayodeji, and A. Azeez, "Performance and accessibility evaluation of university websites in Nigeria", *2022 5th Information Technology for Education and Development (ITED)*, Nigeria, pp.**1–7, 2022.**

[4] S. Sumedrea, C. I. Maican, I. B. Chiţu, E. Nichifor, A. S. Tecău, R. C. Lixăndroiu, and G. Brătucu, "Sustainable digital communication in higher education—A checklist for page loading speed optimization", *Sustainability*, Vol.**14**, No.**16**, pp.**10135, 2022.**

[5] A. Giannakoulopoulos, N. Konstantinou, D. Koutsompolis, M. Pergantis, and I. Varlamis, "Academic excellence, website quality, SEO performance: Is there a correlation?", *Future Internet*, Vol.**11**, No.**11**, pp.**242, 2019.**

[6] S. Sahoo and K. C. Panda, "Web content analysis of Indian Institute of Technology (IIT) library websites: An evaluative study," *Library Philosophy and Practice (e-journal),* No.**3949, 2019.**

[7] S. F. Verkijika and L. De Wet, "Accessibility of South African university websites", *Universal Access in the Information Society*, Vol.**19**, No.**1**, pp.**201–210, 2018.**

[8] T. Jiang, J. Yang, C. Yu, and Y. Sang, "A clickstream data analysis of the differences between visiting behaviors of desktop and mobile users", *Data and Information Management*, Vol.**2**, No.**3**, pp.**130–140, 2018.**

[9] K. Devi and A. K. Sharma, "Framework for evaluation of academic website", *International Journal of Computer Sciences and Engineering*, Vol.**3**, No.**2**, pp.**1–5, 2016.**

[10] N. Menzi-Çetin, E. Alemdağ, H. Tüzün, and Y. M. Merve, "Evaluation of a university website's usability for visually impaired students", *Universal Access in the Information Society*, Vol.**16**, No.**1**, pp.**151–160, 2017.**

AUTHORS PROFILE

Mr. Vikrant Dubey pursued a Bachelor of Science from Dyal Singh College, University of Delhi, in 2019, a Bachelor of Library and Information Science, and a Master of Library and Information Science from the Department of Library and Information Science, University of Delhi, in the Years 2021 and 2022. He is pursuing a Ph.D. from the Department of Library and Information Science, Babasaheb Bhimrao Ambedkar University, Lucknow, since 2024. He is an active Life member of the Indian Library Association (ILA) since 2023. He has published more than 3 research papers at International and National conferences. He worked as an Assistant Professor at MMH College, Ghaziabad, from 2023 to 2024. His main research focuses on Trends in Libraries, ICT, Sentimental Analysis, Data Mining, IoT, Artificial Intelligence etc. He has 1 Year of teaching experience and 1 year of Research experience.

Prof. Shilpi Verma pursued her Ph.D. from Babasaheb Bhimrao Ambedkar University in 2011. She is currently working as a Professor in the Department of Library and Information Science at Babasaheb Bhimrao Ambedkar University, Lucknow, India, since 2006. She has been an active academician and researcher with a keen interest in Information System Management, Information Products Design and Marketing, Information Retrieval and Networks, and Academic Library Systems. Dr. Verma has been a member of the academic and research community, contributing significantly to the field of Library and Information Science. She has published over 50 research papers in reputed international journals, including Scopus-indexed and Web of Science journals, as well as book chapters. Her research focuses on improving information access and management in academic and research environments. With over 19 years of teaching experience and 21 years of research experience, Dr. Verma continues to work towards enhancing library and information systems. She is also actively involved in various academic and professional associations, contributing to the advancement of knowledge in her field.