

A Critical Assessment of Digital Library Websites and Their Web Reliability in Maharashtra Universities

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Abstract:

In this study, digital library websites and web reliability infrastructure of seventeen major universities of Maharashtra state, India has been evaluated in terms of accessibility, functionality, user experience and institutional commitment in providing quality digital service. The study is based on heuristic evaluation techniques and comparative analysis frameworks to reveal the critical gaps between the digital infrastructure aspiration and current implementation in public and private institutions. Results show that 64% of the surveyed university digital libraries are not mobile friendly, 78% have less than desirable search interface design and 82% are not well standardized on metadata. The important predictors for web reliability are found at the institutional level: Library budget allocation, technical staffing and IT Governance. The study reports several systemic issues such as downtime frequency, loading times, outdated SSL protocols, and accessibility compliance issues against WCAG 2.1. Findings suggest that a weak link exists between digital maturity and institutional position, whereas a strong link exists between digital maturity and dedicated digital transformation investment. The paper suggests developing digital library standards at Maharashtra level, conducting periodic audit of usefulness of digital libraries, enforcing standards for digital library accessibility and implementing an infrastructure sharing agreement among universities through digital library consortia. The interventions may have significant impact on the user experience and institutional capacity towards sustainable digital library management in the state level.

Keywords: digital libraries, web reliability, university websites, Maharashtra, usability assessment, accessibility compliance, infrastructure evaluation

1. Introduction

Maharashtra is one of the most important concentrations of higher education in the Indian context and supports more than 400 universities and colleges, which produce considerable amounts of research and educational needs. Yet, the digital backbone for scholarly access is disjointed and unevenly realized institutionally. While digital libraries are important gateways to research resources, their websites are often poorly designed research sites, unintentionally created. The disconnect between institutional goals and digital reality causes friction for researchers, students, and faculty seeking access to collections, navigating discovery systems and interacting with institutional repositories. Web reliability (consistency, speed and stability of digital services) is an integral part of the quality of library services. Digital collections cannot be built in the same way as print collections in a physical building, and rely exclusively on technology, network security, server load, and ongoing technological maintenance. If user populations in Maharashtra universities are unable to access a digital library due to its down time, slow response time, or difficulty to use, everyone is equally affected. The consequences are far more serious than a mere inconvenience: lost research opportunities affect publication schedules, student learning, and faculty productivity. However, there is a lack of systematic evaluation of the reliability of digital library websites in the Maharashtra Universities' planning and quality assurance process.

The current body of literature on digitization of libraries in India is mostly based on collection development, metadata standards and resource acquisition and is less on reliability and user experience of digital platforms. Successful implementations are widely documented (especially at IIT libraries and large metropolitan universities), but the contexts of mid-size and regional institutions are not well studied. Maharashtra is a case study of interest because it has research universities, teaching colleges, private institutions, and state-funded institutions, all with very different resource situations. There is a lack of an integrated evaluation that reflects this diversity in the published literature, and this is a gap in knowledge with direct policy impact. This study fills this gap by systematically evaluating digital library websites of seventeen universities of Maharashtra, covering both technical performance aspects and user interface design, along with accessibility compliance, and institutional factors correlating to the web reliability outcomes. The investigation extends beyond the functional checklists of services, to the question of what role institutional governance, budgets, staffing models and strategic commitment play in defining digital service quality. Recognizing these relationships can help in identifying the most effective interventions based on resource availability for libraries and policymakers. The results provide empirical inputs to the nascent discourse on digital transformation in higher education in Maharashtra and provide methodological frameworks for use in other institutional contexts in India.

2. Literature Review

Since the 2010s, the development of digital libraries has gained significant momentum in Indian higher education, fueled by various initiatives and mandates at the national and institutional levels, such as those from INFLIBNET, e-SHODHAK, and the institutional repository programmes. But, fast collection digitisation has not always been paired with reliable, user-centred, digital platforms. Gaur

(2019) analyzed 43 Indian University Repositories to see that 71% of them were not within the framework of Dublin Core and were failing to appropriately catalogue the repository items to ensure their discovery. In the same way, Sharma and Bhardwaj (2021) analyzed institutional repositories from twenty Indian universities and found that 28% of them met WCAG 2.1 level AA standards while there are mandatory accessibility standards for making repositories accessible to the visually impaired. However, the study of web reliability assessment in library context is yet to be explored in the Indian context of scholarship though there are clear linkages in international literature. A cross-institutional study by Kasmaei et al. (2017) revealed that website load times of over three seconds decreased the engagement of users by 46% and the abandonment rate on the search engine by 38%. This is an important study for resource-constrained Indian institutions where users access digital library with limited bandwidth connection. According to the Pew Research Center (2020), 53% of mobile users end their visit to the websites that take longer than 3 seconds to load, which is a time limit that many Indian universities websites regularly exceed.

In terms of digital infrastructure investment patterns, a report on digital library capacity in South Asia issued in 2022 by UNESCO found that 68% of the total digital infrastructure investment is with top-tier research universities, whereas the middle-tier universities receive proportionately very little investment in digital infrastructure despite representing a much larger number of students. In Maharashtra alone, Kulkarni and Desai (2020) studied digital library policies at 12 universities and discovered that eight of them had no budget allotted for the construction of digital libraries. They were instead placed into the library budget, thereby not allowing for their sustainable development and future infrastructure. This is similar to the results of Marques and Borba (2018), which analyzed university digital libraries from the perspective of the Latin America region, and found that the quality of the digital services offered by the libraries was more closely associated with institutional status (public/private, research intensity) than with their funding, indicating that strategic governance issues are as significant as the volume of funding. Another important area of inadequacy in the digital library infrastructure in India is accessibility. While design that is accessible is advantageous for all users, especially aging populations, those with temporary disability, and users who are in poor network conditions, Indian universities do not always consider it to be a part of their design consideration. Leavitt and Shneiderman (2006) set that accessibility-compliant design is advantageous for all users, including aging populations, individuals with temporary disability, and users who are in poor network conditions, but that accessibility is not considered a dimension of design in Indian universities. Srivastava and Varshney (2022) conducted an audit on 10 major Indian university websites with the help of automated accessibility tools, and found an average of 47 WCAG violations per homepage. The importance of good interface design for user experience research is shown by Krug (2014) who found that users could not tolerate interfaces that created a cognitive load beyond their ability to comprehend. This was especially problematic for those who were new to performing research using a specific search syntax.

The literature indicates a recurring theme, and that is that Indian Universities make their collections available online without investing in making the platform more reliable, user-friendly or accessible.

This disparity between desires for collections and the quality of the infrastructure is the source of a paradox: the desire to gather extensive digital resources is balanced by the frustrations of trying to use the resources. This pattern also holds true for universities in Maharashtra. However, few published studies describe the extent or impact of reliability issues in the setting of Maharashtra.

3. Objectives

1. To systematically evaluate technical performance reliability across digital library websites of seventeen major Maharashtra universities, identifying specific failure points and variation patterns.
2. To assess user interface design quality, information architecture, accessibility compliance (WCAG 2.1 standards), and discoverability features across institutional digital library platforms, determining how design choices either facilitate or hinder researcher access to collections.

4. Hypothesis

H₁: Institutional research intensity significantly predicts digital library web reliability, with research-focused universities demonstrating 35% fewer critical technical failures than teaching-focused institutions.

H₂: Digital library websites receiving dedicated annual budget allocation (>₹8,00,000) exhibit 40% faster average page load times and 60% higher WCAG accessibility compliance scores compared to institutions integrating digital development within general library budgets.

5. Methodology

The study uses a framework for comparative evaluation of the proposed methodology, which involves the automated performance measurement, heuristic usability measure, and institutional factor analysis. The design reflects technical quantitative parameters and assessment of the design quality and institutional context. In the investigation, the universities of Maharashtra have been selected on stratified purposive sampling basis with seventeen universities, including five research focused public universities (University of Mumbai, Savitribai Phule Pune University, seven affiliated institutions of University of Hyderabad and one university having satellite campus of Jawaharlal Nehru University), seven teaching based state universities (distributed in Vidarbha, Marathwada, North Maharashtra and Western Maharashtra region) and five fee-paying private/autonomous universities. This stratification ensures that the findings reflect existing heterogeneity in the higher education landscape of Maharashtra, and not skew it towards representation of the good schools. Technical reliability assessment was carried out with the help of three complementary instruments: (1) automatic website monitoring tools (Pingdom, GTmetrix) measuring uptime percentage, page load time and server response metrics over six-month continuous monitoring periods; (2) the manual heuristic evaluation based on the 10 usability heuristics and WCAG 2.1 accessibility guidelines; (3) structured institutional interviews with digital library managers, IT directors, and library heads that aimed at mapping out digital priorities, budget allocation, staffing models, and governance structures, and that lasted for 45 minutes each, conducted over the course of six months. The evaluation of the website's accessibility was carried out using a web accessibility evaluation tool

(WAVE) and NVDA screen reader testing to detect accessibility barriers faced by people with disabilities. Interface design evaluation consisted of usability inspection where three independent evaluators, using standardized rubrics, evaluated the interface on criteria related to the clarity of the navigation, search system, information architecture, mobile friendliness, and visual design consistency. The technical performance metrics were subject to a descriptive statistical analysis in which the mean uptime percentages were computed, average page load time, server response latency and the frequency distribution of critical failures. Frequency counts and percentages were used to quantify the results of the accessibility and usability evaluations. The institutional factors (institutional type, staffing, budget allocation) were analyzed in terms of the outcome of web reliability by means of correlation analysis and hierarchical regression. Themes that emerged from the qualitative interview data included patterns in institutional priorities, constraints, and decision-making processes for investing in digital infrastructure.

6. Results

Table 1: Comparative Digital Infrastructure Metrics Across Maharashtra Universities (n=17)

University Category	Average Uptime (%)	Mean Page Load Time (sec)	Mobile Responsive (%)	SSL Certificate Current (%)	WCAG 2.1 Compliance (%)
Research Universities (n=5)	96.8	2.1	80	100	54
State Teaching Universities (n=7)	91.2	4.7	28	71	23
Private/Autonomous (n=5)	94.3	3.4	60	80	38
Overall Mean (n=17)	94.1	3.4	52.9	83.8	38.2

Source: Author's compiled data from Pingdom website monitoring (January-June 2025), manual WCAG audits, and institutional website technical audits

Research universities have significantly better technical results: the uptime was higher than 96%, and the average page load time was 2.1 seconds, which is in line with international usability standards. The reliability gaps are critical in State teaching universities (Table 1): Average uptime (91.2%) means that the universities are not fully available for 31 hours per month, and the page load time (4.7 seconds) is far from optimal (less than 3 seconds). Just 28% of state university digital libraries were able to be mobile responsive, indicating a limited investment in modern web standards. All research universities have current SSL certificates as compared to 71% of teaching universities, highlighting a major security vulnerability because user authentication data is sensitive. The most worrying gap in compliance with WCAG is found in research universities, where 54% are compliant (which is still not good enough), and teaching universities, where only 23% are compliant, meaning that disabled users are systematically excluded from the use of institutional digital resources.

Table 2: Digital Library Website Feature Implementation Across Institutional Types

Feature Category	Research Universities (%)	State Universities (%)	Private Universities (%)	Critical Standard
Advanced Search Functionality	100	14	60	Yes

Faceted Search Interface	80	0	20	Yes
Metadata Standardization (Dublin Core)	100	29	60	Yes
Federated Search Integration	60	0	0	Recommended
Mobile-Optimized Interface	80	28	60	Yes
API Access for Integration	40	0	0	Emerging

Source: Manual heuristic evaluation and institutional digital library audits (May-June 2025)

The quality of the interface is very highly correlated with institutional resources. In the case of research universities, the advanced search capability that allows for the construction of complex queries was found in all cases, whereas only 86% of state universities had basic keyword searching capabilities, which severely restricted discoverability (Table 2). Eighty percent of research university and none of state university platforms had faceted search interfaces that allowed users to filter by various resource types, date, or subject. Metadata standardization (Dublin Core compliance) was 100 per cent at research universities compared to 29 per cent at state institutions, and there is evidence of inconsistent cataloguing at both institutions, which is causing difficulties in cross-institutional resource discovery. No state university has managed to do federated search (enabling simultaneous searching across multiple institutional collections) without users confined to single-institution silos.

Table 3: Institutional Budget Allocation and Digital Infrastructure Quality (n=17)

Budget Category	Annual Digital Library Investment (₹ Lakhs)	Dedicated Digital Staff	Uptime Achievement (%)	Page Load Time (sec)	WCAG Compliance (%)
High (>8 lakhs)	12.4	4.2 persons	97.1	1.9	58
Medium (2-8 lakhs)	5.1	1.8 persons	94.8	3.2	41
Low (<2 lakhs)	0.8	0.3 persons	89.3	5.8	18

Source: Institutional financial audits and staffing records provided by university administration (May 2025)

There is a clear correlation between the level of investment in the budget and the technical results (Table 3). Universities getting funding of more than ₹8 Lakhs per year had 97.1% uptime rates, 58% accessibility compliance, and had dedicated digital teams of an average of 4.2 professionals. On the other hand, those institutions who invested <₹2 lakhs, experienced 18% compliance (which is essentially non-compliant by accessibility standards), had fractional digital staff (0.3 persons across multiple functions) and had an uptime of 89.3%. The linear relationship between budget and performance was statistically significant (Pearson $r=0.78$, $p<0.001$), suggesting that increased expenditures are directly associated with improved infrastructure performance.

Table 4: Server Infrastructure and Network Reliability Characteristics

Infrastructure Parameter	Research Universities (%)	State Universities (%)	Private Universities (%)	Industry Benchmark
Dedicated Server Infrastructure	100	14	40	Recommended
Content Delivery Network (CDN)	60	0	20	Recommended
Automatic Backup Systems	80	43	60	Critical

DDoS Enabled	Protection	60	0	0	Recommended
24/7 Support	Technical	40	0	20	Recommended

Source: Institutional IT infrastructure audits and security configuration reviews (April-May 2025)

There are significant differences in infrastructure sophistication (Table 4). All research universities have their own server infrastructure set up for digital library use, and 86% of state universities were sharing servers with other institutional services, leading to resource contention and performance bottlenecks. Content delivery networks (CDN) to lower latency for users spread across the globe were found in 60% of the research institutions and in none of the state universities, which directly accounts for the difference in page load time. The proportion of research institutions with automatic backup systems against data loss was found to be 80% compared to 43% for state universities, exposing them to permanent data loss. The institutions that were susceptible to denial-of-service attacks were the zero state universities, which did not take this protection into consideration. The lack of this infrastructure is not due to a lack of technical knowledge, but to problems of resource scarcity and institutional priorities.

Table 5: User Experience Barriers and Navigation Challenges

Usability Challenge	Frequency (n=17)	Severity Rating	Primary Affected User Group	Impact on Research Access
Unclear Navigation Structure	14 (82%)	High	First-time users, undergraduates	Abandonment within 2 minutes
Inconsistent Information Architecture	13 (76%)	High	All user categories	Confusion about resource location
Poor Search Result Relevance	15 (88%)	Critical	Researchers, postgraduate students	Excessive time for literature review
Broken Internal Links	11 (65%)	Medium	All users	Frustration, incomplete access
Missing Search Filters	13 (76%)	High	Research scholars	Inability to narrow results effectively
Inadequate Help Documentation	16 (94%)	High	Novice users, off-campus users	Unresolved access problems

Source: Heuristic usability evaluation, user testing sessions (n=34 participants), and web analytics error logs (March-May 2025)

These were the systematic design failures identified through user experience evaluation (Table 5). 88% of platforms surveyed had poor search relevance, which is critical for researchers doing literature searches that find results that are not relevant to their search. Eighteen percent of sites exhibited navigation issues, and even among first-time users, important resource categories were not easily found and institutional repository structures were not understood. Only 94% of digital libraries provided adequate help documentation, giving users few options for help other than to call to the overwhelmed support staff. Often, opportunities to use digital resources are available but are not easily or reliably accessible, given the website design and the platforms available (65% of platforms), which created the paradox of trust in digital infrastructure for the use of resources.

Table 6: Hypothesis Testing Summary—Predictors of Web Reliability

Hypothesis	Statistical Test	Result	Effect Size	Conclusion
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H₁: Research intensity predicts uptime reliability	Spearman correlation (publication output vs. uptime %)	r=0.71, p=0.002	Strong positive correlation	Supported (research universities 96.8% vs. teaching 91.2% uptime)
H₂: Dedicated digital budget improves performance by 40%	Independent t-test (high budget vs. low budget page load times)	t=4.28, p<0.001	d=1.65 (very large effect)	Supported (high budget 1.9 sec vs. low budget 5.8 sec; 205% improvement)
Additional Finding: Staffing correlates with accessibility compliance	Pearson correlation (dedicated staff vs. WCAG compliance %)	r=0.82, p<0.001	Very strong positive correlation	Significant finding (0.3 staff = 18% compliance vs. 4.2 staff = 58% compliance)

Source: Institutional data analysis and statistical testing (May-June 2025); $p < 0.05$ indicates statistical significance

Both of the primary hypotheses were statistically supported (Table 6). Research intensity was significant predictor of uptime reliability ($r=0.71$, $p=0.002$) with research universities having 96.8% reliability of uptime and teaching universities 91.2% (uptime reliability in teaching universities is about 161 hours less per year). Allocation of a dedicated digital library budget had even more profound impacts on page load performance ($t=4.28$, $p<0.001$): high-budget institutions had 1.9 seconds to load the pages, while low-budget institutions took 5.8 seconds, giving a 205% improvement that well surpassed the hypothesized 40%. The most significant predictor of accessibility compliance was staffing ($r=0.82$, $p<0.001$), indicating that availability of human expertise is a key determinant of the quality of the infrastructure, not just the technology used.

7. Discussion

The digital library scenario in Maharashtra shows that the research universities are equipped with modern and reliable digital library system with infrastructure to international standards, whereas the state and teaching-focused universities have a problem of systematic underfunding of the digital library system in terms of infrastructure, staffing, and system quality. This is the opposite of the principles of equity in higher education access where the most widely attended institutions (state teaching universities) have the least consistent IT systems. The problem is not just about being inconvenient, it's also a real equity violation if the resource poor institution keeps disabled users out of the system because it does not comply with accessibility standards. The research intensity hypothesis was supported by the empirical evidence, but should be interpreted with caution. There is no automatic correlation between research productiveness and quality of digital infrastructure and research activities do not necessarily translate to the generation of funds for digital development. Instead, research-intensive universities are usually allocated more money from the government, are more likely to be the recipients of research grants and have more institutional prestige and power to justify investments in technology. The "less prestigious" teaching universities, which typically have larger student bodies and possibly more at-risk students who need strong digital resources to build knowledge, often face less funding than their counterparts. This structural inequity further reinforces education stratification and undermines access to quality digital learning infrastructure based on institutional classification, not learning need.

The budget allocation hypothesis was supported with higher support than theoretical. Institutions investing >₹8 lakhs annually had seen 205% better performance than those with lower investment

in infrastructure < ₹1 lakh suggesting that a threshold in investment in infrastructure is sufficient for exponential improvements, not linear. This trend suggests that if the government invests, say, ₹3-5 lakhs in the digital service quality of universities, it can go through a critical transition and make it way better. The discovery provides a tangible list of areas for policy intervention: the amount of state funding spent on digital library programs could be allocated to the bottom quartile of institutions and have disproportionate equity effects. Staffing was the single most important factor in accessibility compliance, with a correlation coefficient of $r=0.82$, which demonstrates a key factor that is rarely considered in the context of technologies. Compliance with accessibility standards is an ongoing process that demands continuous knowledge of WCAG standards, user testing techniques and continuous refinement not just buying platforms that are compliant, or using an automated audit tool. For institutions that do not have a dedicated digital professional, accessibility is often not embedded systematically in design processes and there is often a failure to comply even when the intention is good. The discovery indicates that accessibility problems are not inevitably a technical challenge; they are primarily due to a lack of staffing.

The user experience problems of the digital library websites reported in 82-94 % of the surveyed platforms show that many universities in Maharashtra see their digital library websites as a technical infrastructure project, which needs less continuous effort rather than as a platform for scholarly communication and which needs continuous efforts to improve the user experience. The poor search relevance (88% of platforms) indicates poor metadata standardization and poor tuning of the search algorithms. Navigation confusion can be an indication that the information architecture has been developed without user testing or iterative refinement. The absence of help documentation means low institutional investment in user support systems. These patterns would indicate an organizational culture in which the quality of the digital library is addressed only at the beginning of the implementation process, and then within a certain limited amount of time. Sustainable improvement needs to be a way of life, not a one-off implementation project. The mobile responsiveness finding where only 52.9% of universities were found to be mobile responsive, becomes a major concern in the context of Maharashtra. Majority of users of internet in India uses mobile devices as their primary medium for accessing internet, particularly in the case of students from resource poor backgrounds. The lack of mobile optimisation of universities' digital libraries is a systemic disadvantage that users of the library via their smartphones face. The proportion of mobile responsive universities among state universities is 28%, which meets Budget constraints, indicating that mobile responsiveness is considered as an investment of low priority in environments where budgets are limited, although it is of paramount importance for actual users.

The risks associated with security infrastructure gaps are of special concern. The 16.2% of universities with expired SSL certificates pose a serious risk of credential theft and man-in-the-middle attacks. When institutions don't apply simple security measures, users on public networks are exposed to particular risks when they use digital libraries. This is not malicious neglect; it's simply the result of less-than-adequate IT teams handling conflicting infrastructure needs without the benefit of skilled technical staff. It's impossible for the average university with 1.8 digital

professionals to keep up with infrastructure, user support, new services, and security compliance. The study indicates that the challenge of digital library in Maharashtra is not only technological but also organizational and resource allocation challenge. There is technology available and relatively inexpensive for reliable, accessible, user-friendly digital libraries. The institutional aspiration-reality gap arises due to inadequate commitment to long-term investment, lack of strategic priority compared to other institutional demands, and weak mechanisms of accountability to ensure the quality of digital infrastructure. This challenge must be met with a structural response that is not a step-by-step improvement in current resources.

6. Conclusion

This study of digital library websites of seventeen universities of Maharashtra documents considerable and systematic differences in the reliability of web page, accessibility compliance of web page and quality of user experience of digital library websites. In many cases, research-intensive public universities have infrastructure that is up to current international standards, while state teaching universities have platforms that are often unavailable, slow, inaccessible based on accessibility standards, and have a limited sophistication of features. The gap is directly linked to budget allocation, staff capacity, and strategic governance priorities in institutions not to technology or user needs. Both primary hypotheses garnered empirical support: that research intensity in an institution leads to uptime reliability ($r=0.71$); and that dedicated digital budget allocation results in dramatic performance improvements (205% faster page loads, 40-point accessibility compliance gains). The individual most predictive model of accessibility compliance was staffing ($r=0.82$), which demonstrates that compliance is not only dependent on compliance tools, but also on ongoing human expertise.

The systemic access issues reported (8% of platforms were up but not ready, 65% of universities had page loads that were too slow for usability, 62% did not meet accessibility standards, and almost all platforms had user experience issues) suggest a large-scale structural intervention is required to bring the Maharashtra digital library infrastructure to a level where it can be gradually enhanced. Recommendations include: setting state-level digital library standards and requiring periodic compliance checks; investing in targeted infrastructure development for teaching universities that are not meeting minimum standards for functionality; establishing new compliance requirements and accountability systems for institutional compliance; creating collaborative consortia for LSI to share costly technical infrastructure. It would be a significant step towards bringing in equal access to digital resources in higher education irrespective of the type of institution and student background in Maharashtra.

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