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Enhancing data accessibility in digital repositories: The role of Web APIs and linked data technologies

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Abstract

Digital repositories play a vital role in preserving and disseminating scholarly outputs. However, in many institutions, particularly in developing regions, access to stored data remains fragmented, inconsistent, and difficult to navigate. The core problem lies in outdated interfaces, poor metadata quality, and lack of standardized mechanisms for data exposure. This study investigates how Web Application Programming Interfaces (Web APIs) and Linked Data technologies can enhance data accessibility in institutional digital repositories. A descriptive correlational research design was employed, involving a mixed-methods approach with surveys and interviews conducted in two Kenyan public universities. Findings revealed a moderate positive correlation between Web API and Linked Data adoption and data accessibility (Spearman's rho = 0.367, p = 0.002). Qualitative data highlighted improvements in metadata harmonization and standardized exchange protocols, while implementation challenges included limited technical capacity and inconsistency. The study concludes that institutions implementing standardized APIs such as REST or GraphQL, along with semantic technologies like RDF, significantly enhance users' ability to discover and retrieve repository content. It recommends targeted training, phased deployment, and policy reinforcement to support sustainable implementation.

Keywords: Web APIs; Linked Data; Data Accessibility; Digital Repositories; Semantic Technologies

1. Introduction

Digital repositories are essential infrastructures in the contemporary academic and research landscape. They provide long-term storage, preservation, and dissemination of digital scholarly outputs including theses, publications, and datasets. As institutions transition toward open science, the demand for seamless access to digital content is increasing rapidly. However, most repositories remain functionally limited, offering basic search and retrieval mechanisms without supporting real-time or context-aware data interactions [1], [2]. This gap underscores the need for innovative solutions to ensure digital assets are not only available but also accessible and usable across diverse user groups and platforms.

Web Application Programming Interfaces (Web APIs) provide standardized access protocols that enable external systems and applications to interact with repository content in real time. APIs have become indispensable tools in modern software systems by enabling modularity, scalability, and automation in data retrieval [3]. On the other hand, Linked Data technologies bring semantic depth to metadata by representing it in machine-readable formats using ontologies such as RDF and vocabularies like Dublin Core or FOAF [4]. The combination of these two technologies presents a compelling solution to the accessibility challenges facing digital repositories, as they enhance search precision, metadata enrichment, and data discoverability [5]. Real-time semantic search capabilities, powered by

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Linked Open Data, have also improved the efficiency of digital information retrieval [13]. These semantic frameworks form the foundation for next-generation scholarly communication platforms [17].

Despite the global momentum toward semantic web technologies and open data initiatives, many African repositories, including those in Kenya, continue to rely on static content delivery models [6]. These repositories often lack persistent identifiers, standardized metadata schemas, and interoperable access layers, making scholarly content difficult to locate and reuse [7]. Empirical studies have shown that metadata inconsistency, poor API integration, and inadequate infrastructure are significant barriers to accessibility in institutional repositories across the region [8]. As a result, users, particularly researchers, encounter difficulties in locating, retrieving, and integrating digital content, which compromises research productivity and knowledge dissemination.

The aim of this paper is to assess how the integration of Web APIs and Linked Data can improve data accessibility in institutional repositories. The paper investigates empirical outcomes from two public universities in Kenya, evaluates technical and user-related challenges, and proposes context-appropriate best practices. It contributes to the growing body of knowledge on repository optimization in low-resource settings and supports the realization of open science goals through enhanced repository design. This study complements regional efforts to promote open access through API integration in African academic institutions [12].

2. Methods

This study adopted a descriptive correlational research design to determine the relationship between the use of Web APIs and Linked Data technologies and data accessibility in digital repositories. The design enabled the collection of both quantitative and qualitative data to explain the influence of these technologies on repository usability and discoverability.

The research was anchored in a pragmatic philosophy, combining positivist and interpretivist elements. This allowed for objective measurement through statistical analysis as well as contextual interpretation of user experiences, enabling a holistic understanding of both technological impact and institutional practices.

The target population for the study comprised personnel engaged in both administrative and academic functions within selected public universities in Kenya. On the administrative side, this included repository managers, library support staff, ICT personnel, and senior university administrators. Academics and researchers, including faculty and postgraduate students, formed the second group, offering user-centric insights into repository utilization. This composition ensured a holistic understanding of operational, governance, and usability factors influencing repository design and performance.

A multi-stage sampling approach was employed. Two chartered public universities, Egerton University and Moi University, were purposively selected based on their established repository infrastructure, academic breadth, and digital readiness. These institutions were chosen from a broader consideration set that included other universities, but only Egerton and Moi were used in the main study. Slovin's formula was applied to determine a statistically sound sample size, resulting in a total of 80 respondents: 44 from Moi University and 36 from Egerton University. Further stratified sampling was conducted within each university to ensure balanced representation from administrators, ICT staff, librarians, and researchers involved in the management and utilization of Institutional Repositories.

Data were collected using structured questionnaires and semi-structured interviews. Questionnaires targeted repository users to obtain quantitative data on system usability and accessibility, while interviews with ICT personnel and librarians provided qualitative insights into implementation, policy frameworks, and metadata practices.

Reliability of the instruments was confirmed through a Cronbach's alpha score exceeding 0.70, demonstrating internal consistency. Validity was supported through expert reviews and a pilot study conducted at Kibabii University and Alupe University College, which helped refine data collection instruments prior to the main study. These tools were refined in line with challenges identified in comparative studies on metadata interoperability in local institutions [16].

Ethical considerations were strictly adhered to. Informed consent was secured from all participants, with assurances of confidentiality and anonymity. Institutional research clearances were obtained, and data were handled in compliance with national research ethics guidelines.

3. Results and Discussion

3.1. Common Challenges Affecting Data Accessibility in Digital Repositories

To understand the main barriers hindering effective access to repository content, respondents were asked to identify common challenges they encounter when interacting with digital repositories. Their responses provide insight into technical, structural, and usability issues that may impede data discoverability and retrieval. The summarized responses are presented in Table 1, highlighting the proportion of users affected by various accessibility issues.

Table 1 Common Data Accessibility Challenges

Common Data Accessibility Challenges		**Yes**	**No**	**Total**
Valid	Data not Easily Accessible	30(42.3%)	41(57.7%)	71(100%)
	Poor Metadata Standards	29(40.8%)	42(59.2%)	71(100%)
	Inconsistent File Formats	37(52.1%)	34(47.9%)	71(100%)
	Limited System Integration	31(43.7%)	40(56.3%)	71(100%)
	Lack of Real-time Access	29(40.8%)	42(59.2%)	71(100%)
	Others	0(0.0%)	71(100%)	71(100%)

The findings depicted in Table 1 show that inconsistent file formats emerged as the most frequently reported challenge, identified by 52.1% of respondents. According to Table 1, other major obstacles included limited system integration (43.7%), data not being easily accessible (42.3%), and poor metadata standards (40.8%). A similar proportion (40.8%) cited a lack of real-time access. These results underscore critical structural and technical limitations that affect the usability of digital repositories. Newer models such as GraphQL APIs can help address integration and flexibility issues in repository platforms [9].

3.2. User Satisfaction Metrics on Implemented Data Accessibility Solutions

To evaluate the perceived effectiveness of various solutions implemented to enhance data accessibility and interoperability in digital repositories, respondents were asked to rate their satisfaction on a five-point Likert scale. These metrics reflect the institutions' efforts to address key challenges and provide direction for future interventions. The summarized responses are presented in Table 2.

Table 2 User Satisfaction Metrics on Implemented Data Accessibility Solutions

User Satisfaction Metrics	**1**	**2**	**3**	**4**	**5**	**Total**
Implementing Metadata Standards	10 (14.1%)	4 (5.6%)	17 (23.9%)	30 (42.3%)	10 (14.1%)	71 (100.0%)
Developing or Enhancing WebAPIs	8 (11.3%)	7 (9.9%)	20 (28.2%)	28 (39.4%)	8 (11.3%)	71 (100.0%)
Data Format Standardization	8 (11.3%)	9 (12.7%)	18 (25.4%)	24 (33.8%)	12 (16.9%)	71 (100.0%)
Integrating Linked Data Approaches	11 (15.5%)	10 (14.1%)	16 (22.5%)	28 (39.4%)	6 (8.5%)	71 (100.0%)
Automated Metadata Enrichment Tools	13 (18.3%)	5 (7.0%)	21 (29.6%)	24 (33.8%)	8 (11.3%)	71 (100.0%)
Cross-repository Search Platforms	10 (14.1%)	8 (11.3%)	25 (35.2%)	20 (28.2%)	8 (11.3%)	71 (100.0%)
Interoperability Testing and Protocols	18	7	18	21	7	71

	(25.4%)	(9.9%)	(25.4%)	(29.6%)	(9.9%)	(100.0%)
Training and Capacity Building	13 (18.3%)	11 (15.5%)	14 (19.7%)	26 (36.6%)	7 (9.9%)	71 (100.0%)
Open-source Data Exchange Frameworks	10 (14.1%)	6 (8.5%)	18 (25.4%)	27 (28.0%)	10 (14.1%)	71 (100.0%)
Data Aggregation and Mapping Tools	9 (12.7%)	7 (9.9%)	23 (32.4%)	22 (31.0%)	10 (14.1%)	71 (100.0%)
Collaborating with Other Institutions	5 (7.0%)	1 (1.4%)	41 (57.7%)	18 (25.4%)	6 (8.5%)	71 (100.0%)
Data Access Permissions and Security Protocols	2 (2.8%)	0 (0.0%)	45 (63.4%)	17 (23.9%)	7 (9.9%)	71 (100.0%)

According to Table 2, implementing metadata standards received the highest satisfaction ratings, with 42.3% of users indicating success and 14.1% noting very successful implementation. Table 2 also shows that developing or enhancing Web APIs was viewed favorably, with 39.4% describing it as successful and 11.3% as very successful. Other areas like capacity building, Linked Data integration, and format standardization were also acknowledged as successful to a moderate extent. These improvements align with findings showing that ontology-driven metadata enrichment improves semantic consistency and user experience [10]. Similar satisfaction outcomes have been reported in semantic web-based repository designs within East Africa [14]. The use of persistent URIs and standardized vocabularies further strengthens repository sustainability and data reuse [11].

3.3. Desired Accessibility Features for Web API and Linked Data Integration Solutions

Participants were asked to indicate the most important features they believe should be integrated into Web API and Linked Data-based solutions to improve data accessibility. Their responses reflect core functional requirements expected in a user-centered repository environment. These preferences are summarized in Table 3.

Table 3 Desired Accessibility Features

Desired Accessibility Features		**Yes**	**No**	**Total**
Valid	Seamless Data Exchange	44(62.0%)	27(38.0%)	71(100%)
	Metadata Linking	40(56.3%)	31(43.7%)	71(100%)
	Real-time Synchronization	34(47.9%)	37(52.1%)	71(100%)
	Others	0(0.0%)	71(100.0%)	71(100%)

According to Table 3, seamless data exchange was selected by 62.0% of respondents, making it the most desired feature. Metadata linking was chosen by 56.3%, while real-time synchronization was highlighted by 47.9%. These findings suggest that while automation is important, interoperability and metadata consistency are top priorities in repository system design. Semantic mapping frameworks have also been proposed to address data inconsistency in Sub-Saharan digital repositories [20].

3.4. Relationship Between Web API & Linked Data and Data Accessibility in Digital Repositories

This section presents the results of the inferential analysis conducted to examine the relationship between Web API and Linked Data and Data Accessibility in digital repositories. Given that the normality tests indicated that the Data Accessibility variable is not normally distributed, a non-parametric statistical approach was deemed appropriate for the analysis. Specifically, the Spearman Rank-Order Correlation was employed to assess the strength and direction of the association between Web API and Linked Data and Data Accessibility. The results were as presented in Table 4.

The results in Table 4 indicate a moderate positive correlation between Web API & Linked Data solutions and Data Accessibility, with a Spearman's rho coefficient of 0.367 and a significance level of $p = 0.002$. Since the p-value is less than the 0.05 threshold, the correlation is statistically significant at the 5% level.

This implies that as the implementation and performance of Web API and Linked Data solutions improve, there is a corresponding increase in data accessibility within digital repositories. In other words, the use of standardized APIs and linked data structures is positively associated with users' ability to discover, retrieve, and utilize repository data more efficiently. Standardized API models such as REST have been linked to measurable improvements in data interoperability and access [15].

Table 4 Spearman's Correlation Between Web API &Linked Data and Data Accessibility

			Web API and Linked Data	**Data Accessibility**
Spearman's rho	Web API and Linked Data	Correlation Coefficient	1.000	0.367**
		Sig. (2-tailed)	.	0.002
		N	71	71
	Data Accessibility	Correlation Coefficient	0.367**	1.000
		Sig. (2-tailed)	0.002	.
		N	71	71
**. Correlation is significant at the 0.05 level (2-tailed).				

Qualitative insights from interviews supported the quantitative results. Respondents highlighted improvements in metadata harmonization, real-time data availability, and external platform integration (e.g., ORCID). However, they also cited implementation challenges, such as limited technical skills and inconsistent institutional commitment. These insights align with the findings in [19] that found that successful integration of Web APIs and Linked Data requires not only technical capacity but also leadership and policy alignment [19]. This reflects previous findings that policy alignment and leadership support are key enablers in API integration success [18].

4. Conclusion

This study has demonstrated that Web APIs and Linked Data technologies play a pivotal role in enhancing data accessibility within digital repositories. The findings revealed that while institutional repositories in Kenya face technical challenges such as inconsistent file formats, poor metadata practices, and limited real-time integration, the implementation of standardized APIs and semantic technologies offers a viable pathway to overcoming these barriers. Linked Data practices such as RDF and SPARQL adoption were associated with improved metadata linking and discoverability. The results underscore that while technical tools are critical, institutional readiness, staff capacity, and policy frameworks are equally essential for sustainable repository transformation.

Recommendations

Based on the research findings, this paper makes several recommendations:

- Public universities should prioritize the phased adoption of Web APIs and Linked Data technologies within their digital repositories. This should be accompanied by the use of standardized protocols such as RESTful APIs, RDF vocabularies, and SPARQL endpoints to enhance semantic enrichment and machine-readability.
- Institutions should invest in staff training and capacity building to bridge technical knowledge gaps, particularly among library and ICT personnel.
- National and institutional ICT policies should be updated to explicitly promote semantic interoperability and the integration of open data standards.
- Collaborative partnerships should be encouraged among universities to foster knowledge sharing and promote interoperability through cross-institutional search and metadata exchange frameworks.
- Future research should explore the scalability of these technologies across different repository platforms and assess long-term impacts on research visibility and institutional knowledge dissemination.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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