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Linked Data Technology and Linked Open Data in Academic Libraries in Nigeria: Level of Integration, Challenges and Potential Solution

Okoroma Francisca Nwakaego

Kenneth Dike Library, University of Ibadan, Ibadan, Nigeria

Email address:
frankaonyeka@yahoo.com

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Abstract: The emergence of Linked Data and Linked Open Data technologies in the library and information service environment has altered the platform of bibliographic standards and models. Despite the perception that Linked Data technology will soon be the standard for creating metadata for information resources management in libraries, there tends to be very low level of adoption of this emerging technology in the developing economy. This study examined the level of integration, challenges and potential solutions in the adoption of Linked Data (LD) and (LOD) in academic libraries in Nigeria. Survey research design was adopted for the study. This consists of Questionnaire instrument distributed to Library and Information professionals in Nigeria. Seventy-one responses were received across seventeen higher institutions in Nigeria. The study exposed that most of the academic libraries in Nigeria have not started the implementation of linked data standards at all. The major challenges in the adoption of LD in Nigeria are lack of in-depth knowledge on the potential values and procedural activities of LD and LOD technology amongst librarians and information managers, and poor infrastructure, coupled with the concerns that the system could be hacked. The study identified the need for investment of both social and financial capital into LD technology. Librarians and other key stakeholders should be exposed to trainings and events on LD application. Such trainings can be pioneered by the host institutions.

Keywords: Linked Data, Linked Open Data, Adoption Rate, Academic Libraries, Nigeria

1. Introduction

For some decades, Libraries have transited from MARC-based bibliographic records management using Anglo-American Cataloguing Rules, 2nd edition (AACR2) to Resource Description and Access (RDA) and Bibliographic Framework (BIBFRAME). This is due to the increasing unambiguity of the semantic web, which necessitate that librarians should constantly be on their toes to ensure a synergetic relationship between libraries and the web, as it is usually the first and main point of contact for information seekers. Semantic Web (SW) encourages libraries to collect, link and share their data across the Web in order to enhance its processing by machines, mainly to get better queries and results. BIBFRAME was designed to replace the MARC standards, and to use Linked Data principles to make bibliographic data more useful [14]. The authors [9] affirms that Linked open data is a form of linked data that emphasizes a linked network of data where the data itself is freely available and expressed in machine readable and open source format. That means that the data content is freely available to everyone to use as they wish without any form of restriction from copyright or any other medium of control.

2. Literature Review

In order to make the Semantic Web a reality, there was the need for a set of standards and technologies, to enable computers not only read the data in the system but to understand it well enough to build relationships between different datasets. Linked Data is the set of technologies and standards that makes the SW functional by enabling

computers to read and understand data in such a way that can build relationship between datasets [3, 15]. Linked Data refers to data published in accordance with principles designed to facilitate linkages among datasets, element sets, and value vocabularies [1,]. On the other hand LOD is where the datasets in LD can have unrestricted access. Though, in some instances LD can have some kind of restrictive licensing so as to be closed to some users. The emphasis of LOD is the openness of the data for distribution, reuse, and modification by other systems in the Semantic Web.

According to authors [15], LD is the "best practices approach" of publishing data on the web that allows related information to be connected on the web environment through hyperlinks. Linked Data is expressed using standards such as Resource Description Framework (RDF). In Linked Data, URIs may be Internationalized Resource Identifiers (IRIs), that is, Web addresses that use the extended set of natural-language scripts supported by Unicode. It specifies relationships between things and relationships that can be used for navigating between or integrating information from multiple sources [RDF]. Linked Data includes both URLs as names for things, HTTP URLs in order that users can look up for those names and links to some other URLs, so that users can discover more items. The main requirements for LD are: machine-readable data format; explicitly defined data's meaning; linkage of data to external datasets. Linked Data can also be interpreted as a continuously evolving set of best practices for the publication of structured data on the web, rather than a specific, well-defined technology [6, 10].

There have been numerous advocacies for the integration of Linked Data and Linked Open Data in Library and information system management. Prominent among them is the Manifesto for Linked Libraries, Museums and Archives, which recommended some specific practices for libraries. This include publishing data where people are looking for it (on the Web); publishing and improving data and Linked Data, using semantic web standards to publish structured data, adhering to the Web standards, and publishing information with open licenses. Since then libraries in the United States, United Kingdom and Asia have gotten into some varying level of integration of LD technology into their systems. The National Library of Sweden is a pathfinder in the implementation of LD. Other examples of the development of LD are the German project: the HBZ, the TALIS and LOCAH, a project looking at archive data. These form examples that can be followed. Surprisingly libraries in the developing world are yet to make any tangible progress in the deployment of LD model (Warraich, 2016 and Kumar, 2018). These authors' works have implications on the present study.

Authors [9] found patterns for the linked data and linked open data landscape within the Cultural Heritage domain. According to their findings, there are strong collaborative efforts within each of the individual sectors, as institutions employ linked data and linked open data for their collections' data. Again, they noted that each subdivision had challenges with converting their traditional systems of organization and their description for collections into systems that can manage and model linked data and linked open data structures. But they deployed Wiki-based technologies in all the three sectors in order to explore interoperability and centralized management and access to linked data and linked open data for producers and consumers globally.

For the CONTENTdm Linked Data Pilot, it was organized into three phases: mapping textual metadata to entities, tools for managing metadata, and user discovery powered through use of Wikbase entities (OCLC, CONTENTdm Linked Data Pilot). Authors [15] noted that the tools and technology that were employed in the pilot project which were also used within other linked data and linked open data Cultural Heritage projects are: WIkibase platform, application programming interface (API), OpenRefine software, International Image Interoperability Framework (IiIF) and Javascript Object Notation for Linked Data (JSON-LD). The author reported that Wikibase was used by project partners to enhance their editing, and the management of metadata, structured data, as well as their storage and retrieval functions. While OpenRefine software was used to edit or clean up datasets, (OCLC, CONTENTdm, n.d.). That means that Wikibase is popularly in use for LD and LOD project management.

Numerous Benefits accrue to the integration of LD. linked data and Linked open data are viewed as potentially powerful concepts and tools in shaping a new collections data experience. Linked data makes it easier for people to discover important items that are placed on the Web, thereby making it easier for them to do unexpected, fruitful things with them [7]. According to the authors [14], Librarians perceive that Linked Data technology can enhance navigation between the traditional online tools to access library resources. he following functions of linked data are identified within the OCLC CONTENTdm Data Pilot: It enhances collections, focuses on backend development eg dataset creation/editing, mapping, reconciliation etc., and uses linked open data to advance user experience. Furthermore, the use of linked open data can serve as a pivotal moment for the publishing and sharing of knowledge and data.

As there are innumerable values of LD and LOD to libraries and their services so there are various challenges. Author [4] stated that as the benefits of Linked Data to libraries and their users are potentially great, so are the many challenges to its implementation. Authors [6] collaborates that the complexity of the SW has slowed its expansion, particularly the expertise that it requires (with respect to publishing data and writing applications) was initially too demanding for the majority of users.

On the other hand, Authors [5] categorized the challenges of LD implementation under three main classes, namely; Technical challenges, Conceptual challenges and Legal challenges. The Technical challenges has to do with infrastructural challenges such as data storage means, triple store or database, a webserver, and a resolver that interprets incoming web requests, translates them into queries for the data storage, and returns the results. Conceptual challenges deals with data modeling. There are several ontologies to

choose from; URI Specification. While Legal challenges deal with publication rights and licenses of LD such as inconsistency in legacy data. Again, difficulties exist in understanding SW concepts by library staff members and establishing the links, as well as lack of documentation and advice on how to build the systems [12]. Nevertheless Author [13] assured that the recommendations for LD implementation are practical and can be accomplished without overhauling the entire bibliographic system. That means it is not so difficult to adapt the existing system to LD standards in library system. The author further outlined the National Information Standards Organization (NISO) principles of "good" metadata, such as adhering to community standards, supporting interoperability, using authority control and content standards, clearly communicating terms of use and supporting preservation.

Theafore has identified the background to the adoption of LD and LOD in libraries, the requirements and various benefits associated with technology. It further highlighted the issues connected to the adoption and use of LD technology, and the slow and concentrated implementation effort in the developed nations. Literature reviewed few researches on LD and LOD in the developing nations, and known actually focused on the level of integration, challenges and potential solutions of LD and LOD in academic Libraries in Nigeria. Author [14] affirmed that in the developing countries, there is no tangible evidence on Linked Data usage in libraries except for a few planning efforts. This research aims to fill this gap as it relates to Nigerian context.

3. Objectives

The general objective of this study is to find out the level of integration, challenges and potential solutions to the issues contending with the adoption of Linked Data and Linked Open Data in academic Libraries in Nigeria.

The specific objectives are to:
1. Find out the level of integration of Linked Data and Linked Open Data in Academic Libraries in Nigeria.
2. Examine the various challenges in the implementation of Linked Data and Linked Open Data in Academic Libraries in Nigeria.
3. Identify the potential solutions to the challenges in the implementation of Linked Data and Linked Open Data in Academic Libraries in Nigeria.

4. Methodology

Survey research design was adopted for the study. This consists of Questionnaire instrument with both structured and open ended questions, distributed to Library Information Science professionals in Nigeria. Seventeen higher institutions in Nigeria were represented. Thirteen universities participated in the study, namely; University of Ibadan, University of Lagos, Imo State University, Owerri, Federal University of Technology Owerri, Adeyemi Federal University of Education, Federal University of Agriculture Abeokuta, Ladoke Akintola University of technology, Ogbomoso, Lagos state University of Education Oto Ijanikin, Lagos State, Mountain top University, Lagos, Olabisi Olabanjo University, Nails University, Lagos, Adekunjo Olalekan University and Adeyemi Federal University of Education. Followed by two Colleges of Education (Alvan Ikoku Federal College of Education, Owerri and Adeniran Ogunsanya College of Education), one Polytechnic (Federal Polytechnic, Ayede, Oyo State) and one State Library (Oyo State Library board, I badan).

Both paper and online survey tools were deployed for the study, as each augmented the response rate. Seventy one responses were received across seventeen higher institutions in Nigeria used for the study. Finally the data was reported using simple frequencies and percentage.
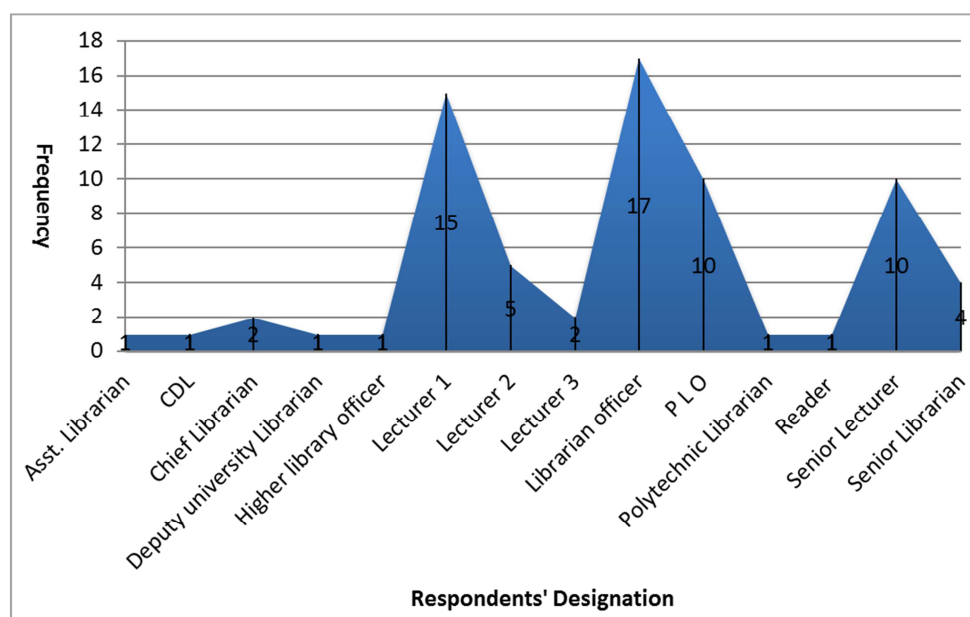

Figure 1. Respondents' Designation in their Universities.

Table 1. *Reasons for Non integration of Linked Data in Respondents Institution as identified in open ended responses.*

Variable	Frequency	Percentage
What are your reasons/fears?		
1. Epileptic power supply and lack of skilled personnel	1	1.4%
2. Inadequate fund	1	1.4%
3. It could be hacked	3	5.6%
4. It has not been brought to our library management discussions	10	14.1%
5. It is a highly technical system	1	1.4%
6. It's not widely known	1	1.4%
7. Lack of man power to implement it	1	1.4%
8. Lack of networking	1	1.4%
9. Lack of trust	3	5.6%
10. My university has not started any planning on LD	1	1.4%
11. Never heard of it	1	1.4%
12. Not yet introduced in our library	1	1.4%
13. Plans are yet in the pipeline for its introduction	1	1.4%
14. Policy issues	1	1.4%
15. We are yet to fully take off	1	1.4%
16. There is no known reason	1	1.4%
17. None	1	1.4%
18. Unaware of LD	1	1.4%

5. Research Findings

Figure 1 shows respondents' designations in their various universities. Most of them were Librarians and Library School Lecturers. 17 (23.9%) of the them were Library officers, 15 (21.1%) were Lecturer 1, 10 (14.1%) were Principal Librarians, 10 (14.1%) were Senior Lecturers, 5 (7.0%) were Lecturer 2, 4 (5.6%) were Senior Librarian, 2 (2.8%) were Chief librarians, 2 (2.8%) were Lecturer 3 while the rest of them Deputy University Librarian, Chief Librarian, CD Librarian and Assistant Librarian had 1 (1.4%) each.

Figure 2 revealed a dismal record of integration of Linked Data and Linked Open Data by Nigerian libraries. Most of them of the respondents 66 (93.0%) opined that their libraries/institutions have not implemented or started to implement linked Data standards for bibliographic records management and dissemination while only 5 (7.0%) confirmed that they have started.
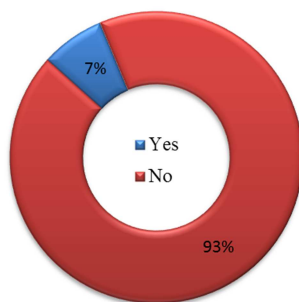

Figure 2. *Level of Integration of Linked Data and Linked Open Data technologies in Nigerians Academic Institutions.*

Table 1 highlighted some reasons for lack of adoption.

Table 1 highlighted the factors inhibiting the implementation of linked data in various respondents' institutions, as listed by respondents' responses to the open ended questions. From the result, 10 (14.1%) of the respondents commented that it has not been raised in their library management discussions, 3 (5.6%) persons opined that there are fears that it could be hacked. Also, 3 (5.6%) respondents identified lack of networking as a limiting factor. Others included epileptic power supply and lack of skilled personnel, inadequate fund, and no planning.

Some others noted that LD is a highly technical system which is not widely known, again there is lack of man power, trust, and policy issues in the implementation of LD in their libraries.

Other reasons given by respondents for none adoption of LD in their institutions presently are as follow:

1. I'm not sure of any planning put in place to implement LD soon in my library.
2. ICT section is now on private partnership.
3. IT team of the college is yet to be constituted.
4. Lack of Policy.
5. Lack of knowledge of LD and LOD.
6. It is the management decision to automate the system.
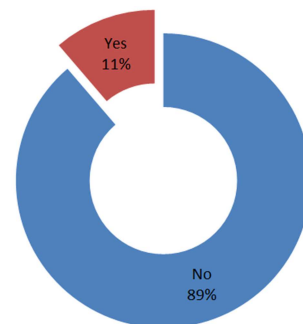7. Lack of manpower to implement it.

Figure 3. *Any plan to implement LD and LOD.*

Figure 3 shows responses of respondents on their plan to implement LD and LOD in their institutions' libraries.

Figure 3 identified responses from respondents on whether there is plan for implementation of Linked Data and Linked open Data in their institutions. Most of them 63 (88.7%) affirmed there is no plan set up to implement LD in their

institutions' libraries. While only 8 (11.4%) indicated there are plans to implement LD in their institutions.

Figure 4 addresses the challenges to the implementation of Linked Data in Nigerian Institutions.

According to Figure 4, the challenges to the implementation of Linked Data and Linked Open Data in academic institutions in Nigeria vary. All the respondents 71 (100%) agreed that lack of awareness and in-depth knowledge on LD technology amongst libraries and information managers are the major challenges.
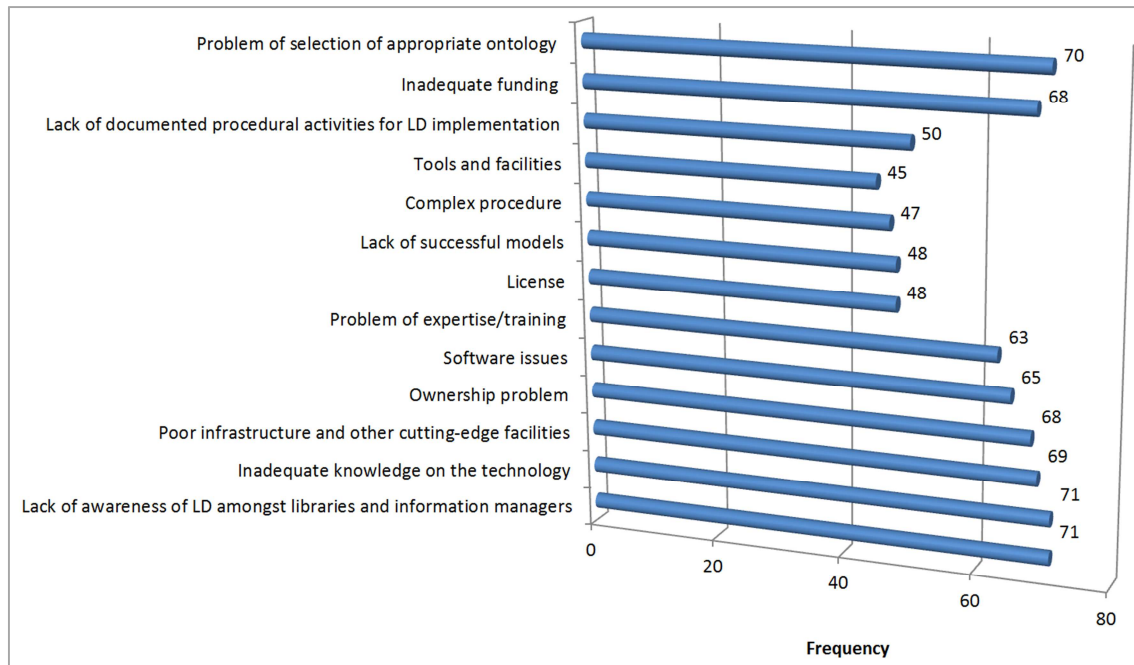
*Figure 4. The challenges to the implementation of Linked Data.*

Other challenges are:
1. the problem of selection of appropriate ontology,
2. poor infrastructure and other cutting-edge facilities,
3. Licensing and ownership problem.
4. Complex procedural activities in the implementation.
5. Problem of expertise needed and inadequate staff.
6. Inadequate funding of academic institutions in Nigeria.
7. Lack of documented LD procedural activities for model in the region.

Other comments by respondents on the challenges to the adoption of LD in Nigeria libraries include the following:

Inadequate power supply, insecurity of equipment and poor maintenance culture, lack of the management of the basic normal data concepts, bad disposition towards libraries by host institutions resulting into poor institutional support towards library projects and programs. Others are complex technological issues, lack of proper training, inadequate tools and facilities, high cost of infrastructure needed (so many institutions cannot afford the system cost especially with the economic downturn).

The techniques to tackle these challenges are highlighted in Figure 5.
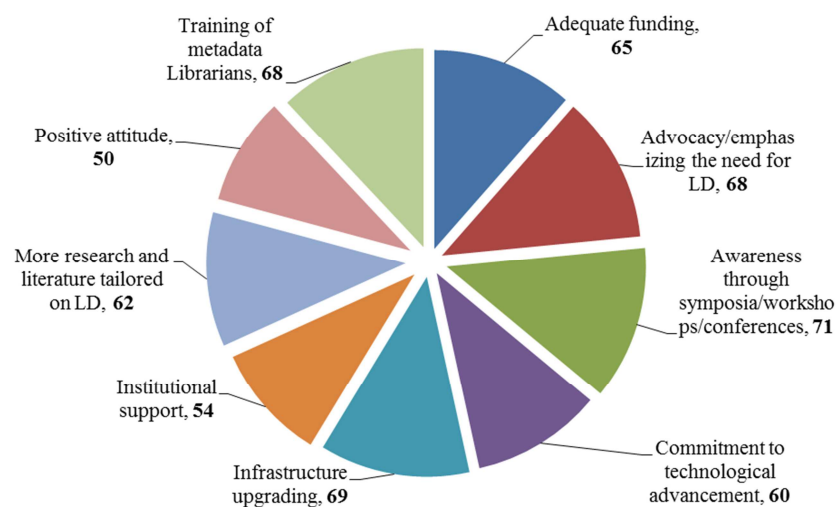
Figure 5. Actions to Improve the Awareness and Adoption Rate of LD and LOD in Nigerian Libraries.

Figure 5 revealed the respondents' opinions on the actions to improve the awareness and adoption rate of LD and LOD in Nigerian libraries. So many action points were brought into the limelight by the respondents. For instance,

All respondents 71 (100%) agreed that awareness and adoption rate can be improved through symposia, workshops and conferences will help improve its adoption. And 68 (96%) added that the awareness/advocacy programmes should emphasize the importance of LD and LOD, make the stakeholders to buy into it. Again, 69 (97%) suggested the need for infrastructure upgrading in the higher institutions in Nigeria, while 68 (96%) agreed that training of metadata libraries will help improve LD adoption as well. On the other hand, 62 persons advocated for more research and literature to be tailored towards LD and LOD, whereas 54 respondents opined that institutional support will enhance the adoption and 50 persons advocated for positive attitude by stakeholders. Furthermore, commitment to technological advancement and adequate funding were identified by 60 (85%) and 65 (92%) persons respectively.

Table 2. *Other Solutions to Effective Implementation and Sustenance of Linked Data and Linked Open Data in Nigeria as Recorded in the Open Ended Question.*

Comments	Frequency	Percentage
Adequate funding	3	4.2
Attending events about LD applications in their data standards in bibliographic records management	1	1.4
Creating extensive awareness on the basic LD concepts	5	7.0
By identifying the perceived hindrances that obstruct LD adoption and effectively implement	5	7.0
In-house trainings	1	1.4
IT staff professionally trained together with librarians for successful implementation and sustenance of LD	7	9.9
The federal government should see to the funding both to state and federal Universities	1	1.4
High institutions in Nigeria should send people abroad to learn how to operate LD system	1	1.4
There is potential to invest in the area of LD technology in terms of social and financial capital	1	1.4
There should be eagerness to attend events about LD	1	1.4
Fostering and funding of research	4	5.6

Table 2 listed the comments by some respondents on solutions for effective implementation and sustenance of linked data and LOD in Nigeria. The suggested consist of the following:

1. IT staff should be professionally trained together with librarians for successful implementation and sustenance of LD.
2. Identifying the perceived hindrances to LD adoption and implementation is key to finding the solutions,
3. Creating of extensive awareness on the technology,
4. Fostering and funding of research in Nigeria.
5. Attending events about LD applications in their data standards in bibliographic records management,
6. In-house trainings of Librarians and other potential drivers of LD,
7. Financial support by the federal government to both state and federal universities,
8. Higher institutions' management in Nigeria need to sponsor staff who will be involved abroad, to learn how to operate and manage the system,
9. Both social and financial capital should be invested into LD technology.
10. Librarians and other key stakeholders should be eager to attend events about LD application.

6. Discussion

The result from the research exposed **t**hat most of the institutional libraries in Nigeria have not started the implementation of linked data standards for bibliographic records management and dissemination at all**.** For many, the issue of adoption of LD and LOD has not even been raised at management level, so planning has not commenced. Authors [14] supported this finding, stating that libraries in the developing world are yet to make any tangible progress in the deployment of LD model.

A major challenge in the adoption of LD in Nigeria is lack of awareness and in-depth knowledge on LD and LOD technology amongst librarians and information managers. Most of the library professionals in Nigeria have not acquired rudimentary knowledge on the emerging technology. Some other challenges to the implementation of linked data and linked open data are: the fears that the system could be hacked. There are concerns that libraries through the implementation of LD and LOD may eventually lose out or lose control of their data to the general public. This is due to the licensing and ownership aspects are still not yet clear to some of the professionals in Nigeria. As a result, the professionals feel that it is not rewarding, to put out the library data to the public considering the effort and resources channelled into data processing in libraries, therefore they still prefer the data to remain in silos.

Again LD and LOD is a high-tech system which is not yet widely known among librarians and information managersand there is the problem of expertise needed to implement the system. Poor infrastructure and other cutting-edge facilities are part of the challenges to the implementation of LD and LOD in Nigeria. This is orchestrated by poor funding of Nigerian public institutions couple with the rising cost of resources procurement with the devaluation of Nigerian currency. This agrees with authors findings [5] which categorized the challenges of LD implementation under three main classes, namely; Technical challenges, Conceptual challenges and Legal challenges.

These call for both the need for adequate training of manpower and commitment to technological advancement in the academic system as well.

Furthermore, the problem of insecurity in the country, resulting from high rate of insurgence and cyber crimes in Nigeria and the world over, has reduced the level of trust among individuals and organisations. This has slowed down the rate of award of contracts and ushered in prolonged delay in the execution of projects in Nigerian higher institutions.

Other issues are the problem of selection of appropriate ontology, policy issues, lack of documented LD procedural activities as models to follow, poor maintenance culture, and bad disposition towards libraries by host institutions resulting into poor institutional support to library programs and projects. Although there are successful examples of LD implementation, but they are more prominent in the advanced economy where appropriate structures are put in place (e.g. constant supply of energy, hardware and software continual upgrading and maintenance as well as constant internet supply) and the systems are working consistently to keep sustaining what is on ground. However in the African context there is scarcity of success stories to the use of the models. Again some of the host institutions do not give their libraries the support and priority that they deserve, so accessing adequate resources to implement new technologies becomes a problem.

Some of the issues raised are in harmony with literature. For instance authors [9] noted that in the pilot project which were also used within other linked data and linked open data Cultural Heritage projects, each subdivision had challenges with converting their traditional systems of organization and their description for collections into systems that can manage and model linked data and linked open data structures.

So many action points were brought into the limelight in the study as proposed solution towards the implementation of LD and LOD. Number one on the list is to identify with and begin to analyze the perceived hindrances to LD adoption and implementation, as it is a key to finding the solutions. It is therefore imperative that similar studies should be conducted in each institution and other countries to identify their peculiar situations' and needs. Generally, more research and literature need to be tailored towards LD and LOD in order to resolve the contending issues.

Another key finding for high adoption of LD in Nigeria is the need for investment of both social and financial capital into LD technology. Librarians and other key stakeholders should be exposed to trainings and events on LD application. This can be pioneered by the host institutions.

The study further identified that the awareness and adoption rate can be improved through organizing various programmes by the institutions' management, e.g. symposia, workshops, and conferences with emphasizes on the importance of LD and LOD, as such will help the stakeholders to grasp the importance and how they will gain from the implementation of the technology. This will help them to buy into it.

7. Conclusion

There is a drastic low level of integration of linked data standards in the academic libraries in Nigeria, just a few institutions are at conceptualization stage. This can be attributed to the varied levels of issues such are lack of in-depth knowledge on the subject of LD and LOD technology amongst librarians and information managers, and inadequate infrastructure amongst others. Some of these problems are peculiar with the developing economy. To hasten the adoption rate of Linked Data technology in academic libraries in Nigeria, institutional and government support policies should be set up to ensure appropriate infrastructural procurement and upgrading in the higher institutions in Nigeria, as well as training opportunities for metadata librarians who will manage the system.

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