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# Mapping Knowledge Hierarchy on Digital Library from 2007-2017:

## A comparative study of India, China and United States

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### Abstract

**Purpose:** This study aims to provide a comparative analysis on knowledge hierarchy taking into account countries such as India, China and United States of America on digital library perspective research from 2007 to 2017.

**Methodology:** This study covers articles published in the Web of Science database where 242 articles were taken into consideration and further analysis was done for the stipulated time period.

**Findings:** The research trend of digital library in India consists of 15 core topics and other specific areas, China with 15 core areas as well for the same time period and U.S.A showed 17 core topics for research in digital library topic. The countries most researchable areas as well as related researchable areas has been analysed here. The growth of digital libraries in these countries are highlighted with appropriate diagram.

**Originality:** Here the articles were extracted from Web of Science database for obtaining necessary findings. Major highlighted topics of India were digital library architecture/infrastructure (20.58%), whereas digital library services (11.76%) was the most researchable area of China and USA emphasised more on digital library collections (19.74%).

### Keywords:

Digital Library, core topics, subtopics, comparative analysis, Country wise growth, India, Peoples R China, U.S.A

### 1. Introduction:

Technological advancement of libraries tend to come in a digital age. Digital library (DL) concept gained much popularity in the age of information explosion. A Digital Library is a particular kind of information system and consists of a set of components, typically a collection (or collections), a computer system offering diverse services on the collection (a technical infrastructure), people, and the environment (or usage), for which the system is built. When designing a DL the initial points are its intended usage and the corresponding user needs. The model is based upon the assumption that the user and the user needs specify the major requirements with respect to their range and content of the collections. The nature

of the collections will predetermine the range of technologies that are needed. The charisma of the collections to the users and the ease of use of the technologies by user group will determine the extent of the usage of the DL [Fuhr, 2006]. These countries were taken into consideration as India is a developing country whereas Peoples R China and USA are the major leaders as a technologically advanced country .Here India, Peoples R China and U.S.A took as a sample country based on these countries published articles we did a comparative study and analysed our data with graphical presentation.

## **2. Objectives:**

1. To find year wise growth of digital library among the countries (India, Peoples R China and USA) for the duration 2007-2017.
2. To highlight the specific areas of research in digital library for the above mentioned countries.
3. To determine the knowledge hierarchy in development of digital library.
4. To discover various core topics and subtopics of these countries.
5. To create a comparison on the research field area of digital library between India, Peoples R China and USA.
6. To unearth the major researchable areas taken up by these countries on digital library.

## **3. Literature Review:**

One of the challenges of digital libraries discussed by Sadagopan (2000) includes availability of information at the fingertips but questions, where is knowledge. Digital libraries in the Indian context are discussed and the author highlights the opportunities available to library scientists for creating and accessing content in Indian languages. Sreenivasulu (2000) authored one of the earliest papers looking at this aspect with particular reference to the emergence of the 'digital librarian'. The paper describes an array of roles for the digital librarian and discusses the competencies, skills and professional education and training needed by the digital librarians. Srivastava and Saxena (2004) have written an overview of digital libraries. Sharma and Arora (2005) highlighted the need for digital libraries along with the requirements, digitization process and future of digital libraries. James (2005) looks at digital libraries and copyright including various issues with respect to the different aspects of digitization and the copyright laws of India. This article points out that technical issues predominate and that legal issues are not given adequate attention in the digitization process. Ravi, Chandra and Sharma (2000) look at emerging trends and the future of digital libraries in terms of their usefulness and cost effectiveness. Das and Dutta (2004) discuss the need for audit and control of digital library systems. The authors identify the elements of audit and control that enhancing the capabilities and effectiveness of digital libraries. The issues and strategies involved in management of digital libraries include hardware management, software management, collection management, preservation/archiving, financial management and the access system are focused on by Gupta and Singh (2006). Varatharajan and Chandrashekhara (2007) explored the application of digital library initiatives to promote higher education in India. Zhao and Zhang (2011) identified the research paradigms on

Digital libraries in China compared to international Digital library research. They examined 1250 papers published between 1994-2010 from the CNKI and Science Direct databases with topic search on digital library. They showed the evaluation on digital library in China. Mane and Panage (2014) studied on web based delivery of context and related access services to cater the information needs. They examined a multi tire architectures and applications such as portal.

#### 4. Methodology:

The data was extracted from Web of Science database on 22<sup>nd</sup> September, 2018. For this we entered Database core collection of web of science then limited our basic search with the topic “digital Library” and customised year ranging from 2007 to 2017. Out of the total 1138 articles, 607 articles were related to the field of information science library science. Then we further restricted our search country wise and selected 34 articles for India, 51 articles for China and 157 articles for U.S.A. The refined data was fed into Zotero to arrange the entire data in an organised manner. The data was also screened using Spreadsheets for further analysis to obtain relevant findings.

#### 5. Digital Library Relationship:

Digital library is a vibrant topic for new age information dissemination. So before carefully examining these three countries we had to understand the relationship of the topic with other sub topics. According to LCSH Digital Libraries have indicated three important relationships. These are:

**Table 1: Relationship structure of Digital Library**

Relationship types	Terms included relationship
Equivalence (It can be synonymous terms, abbreviations, acronyms, variant spellings, initials, Different language terms, popular and scientific terms, alternative forms, different entry elements, opposite terms not used as headings and narrower terms not used as headings)	Digital curation Digital media collections Digital media libraries Digital repositories Electronic libraries Electronic publication collections Electronic publication libraries Electronic text collections Repositories, Digital Virtual libraries
Hierarchical (It can be Genus/species, Whole/part and Instances)	Libraries Art—Digital libraries Children's digital libraries Computer science—Digital libraries Education—Digital libraries Education, Higher—Digital libraries Europe, Eastern—Digital libraries Humanities—Digital libraries Institutional repositories Mathematics—Digital libraries Science—Study and teaching—Digital

	libraries Social sciences—Digital libraries Z39.50 Profile for Access to Digital Collections
Associative (It can be happened to link two terms with overlapping meanings, to link a discipline and the object studied and link a class with its field of work)	Information storage and retrieval systems Web archives

**6. Country wise analysis:** Based on this we tried to find out country wise development and their core topics and sub topics

### 6.1 Digital Library analysis of Indian Perspectives:

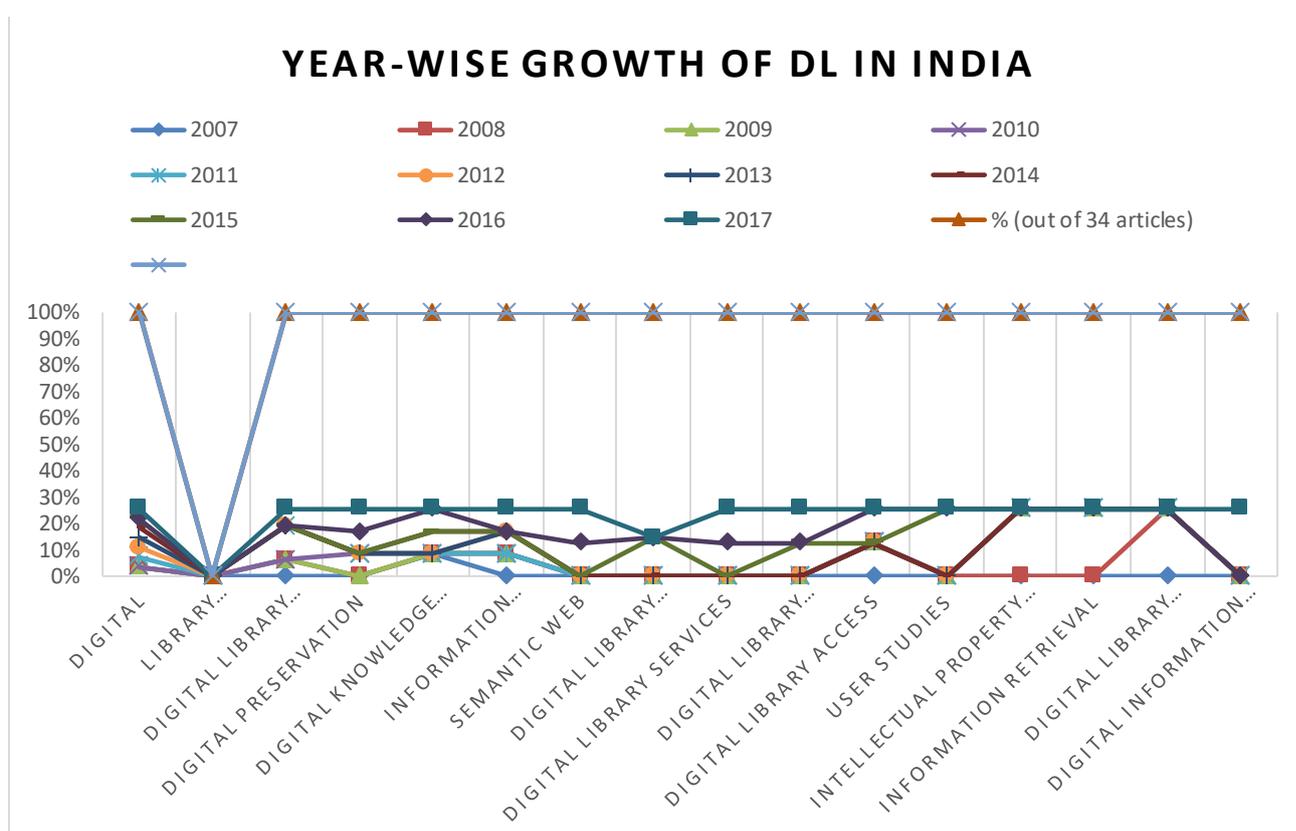
India is one of the developing countries in Asia. But Library and information science took this country to a global forum. With the technological innovation India also took to platform where libraries can achieve their goal in a digital era. After collecting database we found that out of 34 articles the researchable areas of this country are Digital library architecture and infrastructure(20.58%),digital library research and development(11.76%),information organization in digital era(8.82%), digital preservation(8.82%), digital knowledge management(8.82%), Digital library collections(5.88%), Semantic web(5.88%), Digital library education(5.88%), Digital library services (5.88%) digital information literacy (2.94%), User studies(2.94%), Intellectual property, privacy, security(2.94%), Information retrieval(2.94%), Digital library access(2.94%), Digital library application(2.94%).

**Table 2. Year-wise Publication of Articles for India**

Topic	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	% (34 articles)
Digital library architecture/ infrastructure	1				1	1	1	1	1		1	20.58
Digital library research and development		1			2						1	11.76
Digital preservation				1						1	1	8.82
Digital knowledge management	1							1		1		8.82
Information organization		1				1					1	8.82
Semantic web										1	1	5.88
Digital library education									1			5.88
Digital library services										1	1	5.88

Digital library collections									1		1	5.88
Digital library access		1								1		5.88
User studies									1			2.94
Intellectual property and security			1									2.94
Information retrieval			1									2.94
Digital library application		1										2.94
Digital information literacy											1	2.94

**Chart 1. Year-wise graphical pattern of Digital Library for India**



**Result:**

In India 15 core topics were analysed. Out of these the most researchable area is found to be digital library architecture and infrastructure (20.58%). Other topics were further subdivided into different areas. Table 3 shows that relationships:

**Table 3. Core topics and subtopics of India**

<b>Sl. No.</b>	<b>Core-topics</b>	<b>Sub-topics</b>
1.	Digital library architecture/ infrastructure	Software -Open source software (3) -Open source tools (1) Architecture -Information Model (2) Digital Objects -Object oriented modelling.(1)
2.	Digital library research and development	Research and development -Digital library research(1) -Digital library development (1) -Interdisciplinary research (1) International Cooperation -Digital library collaboration (1)
3.	Information Organization	Metadata -Thesaurus(1) Bibliographic Data -Union Catalogue(1) Structured documents -Mark up languages(1)
4.	Digital preservation	Repositories -Institutional repositories(2) -Open source repositories(1)
5.	Digital Knowledge Management	Knowledge Management -Knowledge organization systems(1) -content management(1) Knowledge Process -Knowledge acquisition(1)
6.	Digital Library Services	Services -personalized information services(1) -online information services(1)
7.	Digital Library Education	Digital library training(1)
8.	Semantic Web	Ontologies -ontology services (2)
9.	Digital Library Collections	Collections -Resources(1) Multimedia collections -educational resources(1)
10.	Digital Information literacy	Information literacy -Computer literacy(1)
11.	User Studies	Information seeking behaviour(1)
12.	Intellectual property and security	Intellectual property -copyright protection(1)
13.	Information Retrieval	Search -Search method(1)

14.	Digital Library access	Access -Open access(2)
15.	Digital Library application	Research -Scholarly communication(1)

**6.2 Analysis of China:** Peoples R China is a developed country popularly known for its population and technological advancement. Out of the selected 51 articles research areas focus primarily on digital library services(11.76%), information organization(9.80%), user studies (9.80%), Digital knowledge management (9.80%), Digital library applications(7.84%), digital library research (7.84%), information retrieval(5.88%), digital library architecture/ infrastructure(5.88%), intellectual property, security(5.88%), semantic web(5.88%),virtual technologies(3.92%), international collaboration and development(3.92%), digital access(3.92%), mobile technology(3.92%), digital library collections(3.92%)

**Table 4. Year-wise Publication of articles for China**

Topic	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	%( 51 articles)
Digital Library services		1			1	2		1	1	1		11.76
Information organization						1		1		1	2	9.80
User studies		1						1		2	1	9.80
Digital knowledge management				1		2		1	1			9.80
Digital Library application			1				1	2				7.84
Digital Library research			1				1			1	1	7.84
Information retrieval							2			1		5.88
Digital library architecture/ infrastructure			1						1	1		5.88
Intellectual	1									2		5.88



**Result:** In Peoples R China 15 core topics were identified based on our findings. The refined results focus on researches on information resource, ontology, semantic web, semantic search, electronic government, information resource management, knowledge management, knowledge innovation, knowledge sharing, knowledge organization, network, information service, information need and digital library. The research fields of LIS in China are varied. Many of these research fields are not so vast; the well-developed core research fields are few. But the core areas indicate various subtopics of LIS field. These areas were found while collecting data are as follows:

**Table 5: Core topics and Subtopics of Peoples R China**

Sl. No.	Core-topics	Sub-topics
1.	Digital library services	services -Reference services (2) -Information services (1) -Web services (1) -Three dimensional extension service (1) -Visual impairment web service (1)
2.	Digital library research & development	-Development of digital library (1) -global collaboration (1) -Digital library concepts (1) -Digital library research (1)
3.	Information organization	-metadata harvesting (1) -automatic indexing (1) -hierarchical structure (1) -data mining (1) -big data (1)
4.	User studies	-information seeking behaviour (3) -user need (2)
5.	Digital library collections	Resources -Multidisciplinary (1) Databases -Web databases (1)
6.	Information retrieval	Search -search strategies (1) -heterogeneous search (1) -meta search (1)
7.	Digital architecture/infrastructure	Computing -ubiquitous computing (1) Heterogeneous -large scale systems (1) -networking (1)
8.	Mobile technology	-web digital library in mobile library (1) -mobile library interface (1)
9.	Digital knowledge management	-knowledge organization systems (1)

		-knowledge acquisition (1) -knowledge mapping (1) -knowledge evolution (1)
10.	Intellectual property and security	-information security (1) -copyright infringement (1) -intellectual method in Digital library (1)
11.	Digital access	-open access (2)
12.	Digital library application	-java based digital library (1) -e-learning (1) -application of dataspace (1) -digital library initiative (1)
13.	Virtual technologies	-virtual reference service (2) -virtual method for measuring e-quality (1)
14.	Semantic web	Semantic search -keyword search (1) Ontologies -ontology services (2)
15.	International collaboration and development in digital library	-international collaboration (1) -International development (1)

### 6.3 Analysis of U.S.A:

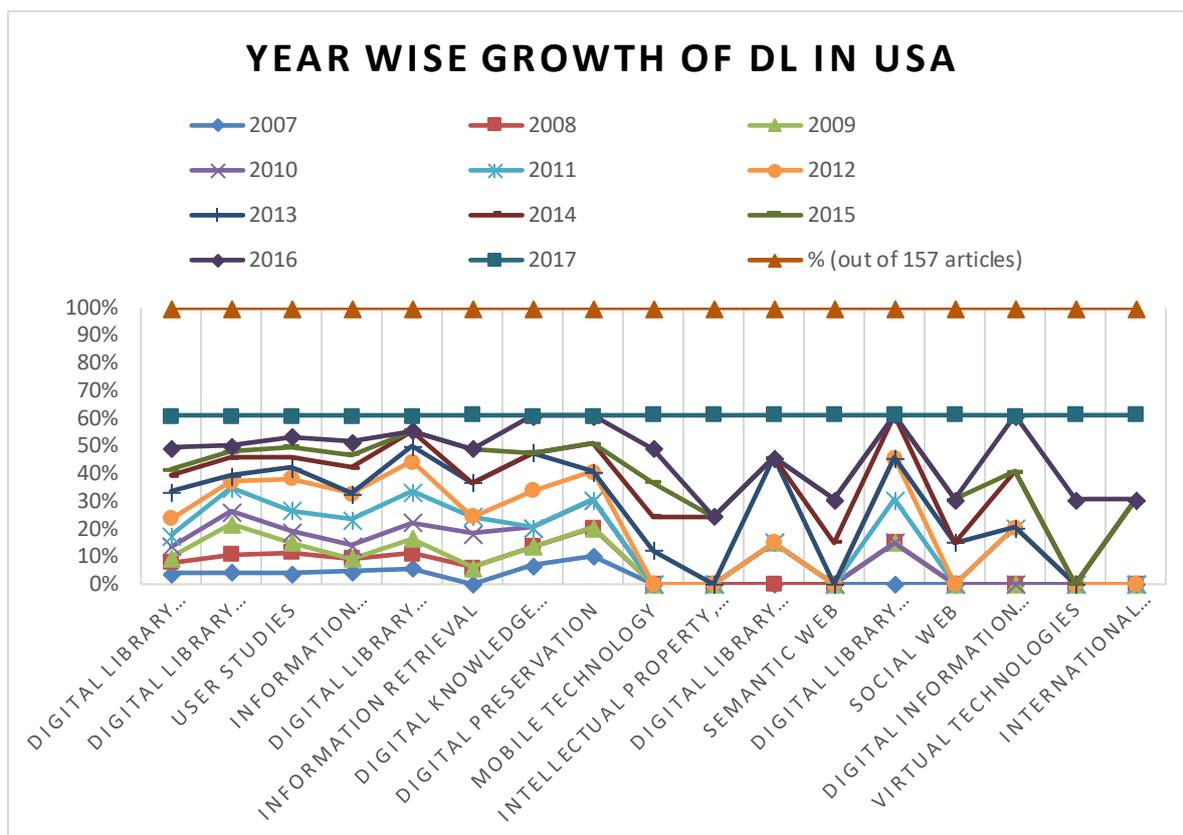
Out of 157 articles in U.S.A the researchable areas are digital library collections (21.01%), digital library architecture/infrastructure (17.83%), user studies in digital era (10.19%), information organization in digital era (8.28%), digital library applications (7%), information retrieval (6.36%), digital knowledge management (5.73%), digital preservation (3.82%), mobile technology in digital library (3.18%), Intellectual property, privacy and security (3.18%), digital library education (2.54%), semantic web (2.54%), Digital library management (2.54%), social web (2.54%), Digital information literacy (1.91%), virtual technologies (1.27%), international collaboration and development (1.27%). Table 6 shows the year wise growth chronologically.

**Table No.6: Year wise growth of United States of America**

Topic	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	% (157 articles)
Digital library collections	2	2	1	2	2	3	5	3	1	4	6	19.74
Digital library architecture/infrastructure	2	3	5	2	4	1	1	3	1	1	5	17.83
User studies	1	2	1	1	2	3	1	1	1	1	2	10.19
Informatics	1	1		1	2	2		2	1	1	2	8.28

ion organiza tion												
Digital library applicati on	1	1	1	1	2	2	1	1			1	7
Informat ion retrieval		1		2	1		2		2		2	6.36
Digital knowled ge manage ment	1	1		1		2	2			2		5.73
Digital preserva tion	1	1		1		1		1		1		3.82
Mobile technolo gy							1	1	1	1	1	3.18
Intellect ual property and security								2			3	3.18
Digital library educatio n			1				2				1	2.54
Semanti c web								1	1		2	2.54
Digital library manage ment		1			1	1		1				2.54
Social web							1		1		2	2.54
Digital informat ion literacy					1			1		1		1.91
Virtual technolo gies										1	1	1.27
Internati onal collabor ation and develop ment							1				1	1.27

**Chart 3: Year wise graphical pattern of USA**



**Result:**

The topic hierarchy of a research field can help us better understand its intellectual structure. This paper proposes to discover the specific topic hierarchy. In USA out of 157 articles 17 core topics were found. The subtopics which include specific areas of research in digital libraries are databases of various collection, such as manuscripts, music libraries etc. Various software's, cloud computing, grid computing have taken the place of development in digital library architecture. Apart from this In USA the digital library research took a path of new age development. As a developed country user studies, information organization, information retrieval, digital preservation, semantic web etc. have changed research field in an innovative way. Like advancement of technology and innovation its research areas in digital library concept gave a flash of upcoming development in this field.

The areas are as follows:

**Table 6. Core topics and Subtopics of USA**

Sl. No.	Core-topics	Sub-topics
1.	Digital library collections	Collections -Resources(3) Database -Music database (4) -Video database (2)

		<ul style="list-style-type: none"> <li>-Image database (2)</li> <li>Multimedia</li> <li>-Manuscripts(6)</li> <li>-Heritage collection (3)</li> <li>-Digital Music Libraries (4)</li> <li>-Digital talking Books (4)</li> <li>-Digital video libraries (3)</li> </ul>
2.	Digital library architecture/infrastructure	<ul style="list-style-type: none"> <li>Software</li> <li>-digital library software(5)</li> <li>-artificial intelligence (2)</li> <li>-computer games (3)</li> <li>Computing</li> <li>-cloud computing (2)</li> <li>-grid computing(3)</li> <li>-ubiquitous computing(1)</li> <li>Algorithm</li> <li>-probabilistic model(1)</li> <li>Architecture</li> <li>-information model(1)</li> <li>-Middleware(1)</li> <li>Network</li> <li>-world wide web(2)</li> <li>-Web 3.0(2)</li> <li>-blogs(3)</li> <li>-spatial data(1)</li> <li>-embedded systems (1)</li> </ul>
3.	User studies	<ul style="list-style-type: none"> <li>Users</li> <li>-web community(3)</li> <li>-blind users(2)</li> <li>-Research groups user(3)</li> <li>Usage pattern</li> <li>-weblogs(2)</li> <li>-query logs(1)</li> <li>Information need</li> <li>-user requirements(3)</li> <li>User studies</li> <li>-information seeking behaviour(1)</li> <li>-user perception(1)</li> </ul>
4.	Information organization	<ul style="list-style-type: none"> <li>Metadata</li> <li>-metadata management(2)</li> <li>-metadata aggregation (1)</li> <li>-thesaurus(2)</li> <li>Structured documents</li> <li>-mark up languages(1)</li> <li>Discovery</li> <li>-data mining(2)</li> <li>Information processing</li> <li>-encoding(1)</li> <li>-text clustering(1)</li> <li>-image processing (2)</li> </ul>

		-automatic indexing (1)
5.	Digital library application	Research -research institutions(3) Learning -e-learning(2) -taxonomy learning(2) Application -children digital library(2) -disability digital library(2)
6.	Information retrieval	Multilingual -cross languages(2) Search -full text search(3) Query -query formulation(2) Browsing -web browsing(1) -document browsing(1) Filtering -collaborative filtering(1)
7.	Digital knowledge management	-Knowledge process(2) -knowledge representation(1) -knowledge extraction(2) -knowledge exchange(1) -knowledge mining(2) -collaborative knowledge(1)
8.	Digital preservation	Preservation -cultural heritage preservation(1) -digital museums(1) -digital curation (1) Storage -digital image storage(1) Repositories -online repositories(1) -institutional repositories(1)
9.	Mobile technology	-mobile user interface(2) -mobile services(2) -wireless network(1)
10.	Intellectual property and security	Security -data security(2) Intellectual property -digital rights management(3)
11.	Social web	User generated -Folksonomy(2) -social tagging(1) -crowd sourcing(1)
12.	Semantic web	-semantic model(2)

		-semantic search(1) Ontologies -domain ontology(1)
13.	Digital library management	Policy -digital library policy(1) Human resources -information professionals(1) Evaluation -performance improvement(1) Quality -quality assessment(1)
14.	Digital library education	-digital library programme(3) -digital training(1)
15.	Information literacy	-digital divide(2) -information ethics(1)
16.	Virtual technologies	-virtual reality(1) -3D digital preservation(1)
17.	International collaboration and development	-international collaboration(2)

## 7. Interpretation and Analysis:

Here a comparative study on hierarchical development of the three countries were taken on an individual view .In India we have seen that most of the researchable works were done on the analytical phase with theory as well as structural phenomena. From 2007 to 2017 India took a continuous growth of digital library which gave more diffusion on architecture/infrastructure (20.58%) of it. Various open source software's like Koha, NewGenlib, D-space, Greenstone digital libraries, information model and object oriented modelling took a new interesting phase of research. Theoretical perspectives of digital library research made a clarity on the evaluation from an early stage to the present age. Preservation of online repository, semantic web application, information literacy for the digital library staff, searching method of users are all included here. Digital library consortium like INFLIBNET also paved a positive way for the growth in digital library.

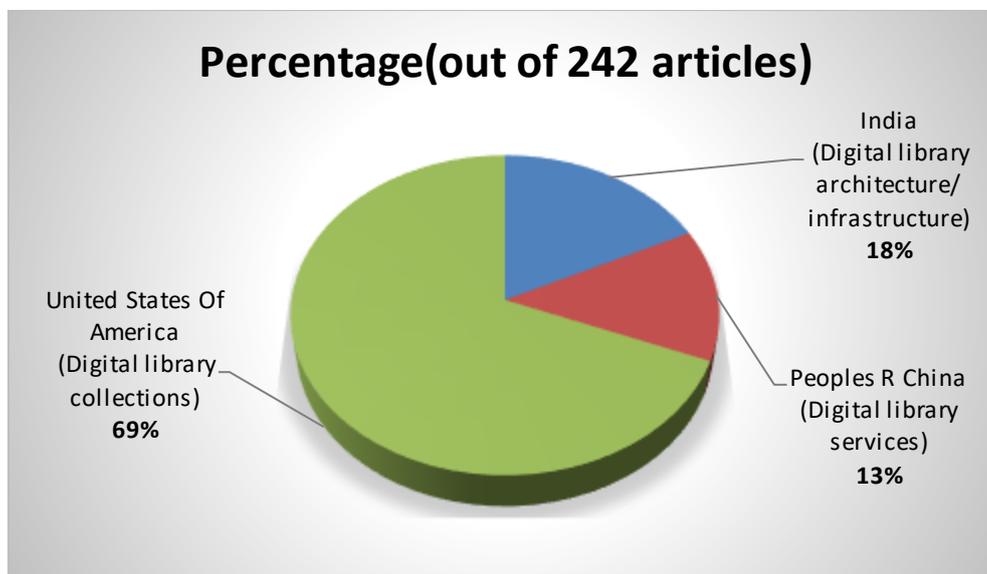
In Peoples R China 2007-2017 digital library services (11.76%) took a good vision in DL topic. Big data, data mining, virtual technologies, searching and browsing application like open access infrastructure is more related to that topic. In digital knowledge management knowledge visualization, knowledge acquisition are included. Application of ontology, three dimensional extension in digital library, semantic web management, mapping knowledge management all are included here. From 2012 to 2017 more emphasise were given on the thesaurus automation, application of data space, crowd sourced digital library, mobile digital library, user perception in digital era, knowledge tagging, digital rights management, effect of social media, hierarchical segmentation of structured digital library, collaborative innovation about big data all are included this phase.

**Table 7. Over all development of three countries**

Country	Major Researchable areas	Percentage (out of 242 articles)
India	Digital library	3.30

	architecture/infrastructure	
Peoples R China	Digital library services	2.47
United States Of America	Digital library collections	12.80

**Chart 4. Country wise distribution based on Percentage**



In United States of America most researchable area identified were digital library collections (19.74%). Here a broader perspectives created a difference between the other two countries. The databases included music, video, image databases. Interactive systems on server realities, information visualization, application of ontologies, and visual classification, and cross-cultural multilingual digital library, project on metadata model, context sensitive searching, information communication technology, information seeking and retrieving, hypertext and holistic model are discussed here. From 2012-2017 qualitative analysis for digital collection, ambiguous author query detection for crowd sourced digital library, digital humanities, data mining, augmenting Dublin core metadata for digital library, digital archives its development, design issues accessibility for blind users, digital collaboration, professional training, digital library consortia, machine learning and tailored news article taxonomy, metadata standards, HathiTrust Digital library all are given new areas.

So, it is identified that development in the above mentioned countries on digital libraries is based on two main perspectives: technical and economic issues. Technological obstacles overcome progress in computers, networks, and algorithms. Economic issues have also made a change in digital environment as it took much developed infrastructure than traditional libraries. So economic advancement of a country also helps in its structural development in any field. Developed country like USA is very diffusive about their infrastructural innovation. New areas are taken as a research areas in digital library field as we have found in finding subtopics. Peoples R China is more developed compared to India but narrower than USA. India is trying to elaborate more new areas in research. Most of the works are experimental with analytical analysis and segmentation in clear.

## **8. Conclusion:**

These results have been a combination of new research results and new activities. The development of digital libraries has been a mixture of change. There are ideas which were invented long before users, and other ideas such as search engines which appeared suddenly when opportunities arose. Output of this comparative studies shown that everyday new concept will come in digital library as it is a very big concept. We have tried our best to illustrate the precise core areas of digital library research. Effort has been made to give knowledge hierarchy on this topic. Peoples R China and India are developing countries whereas USA is developed so technological advancement affects much. It is not comparable to the innovation of USA with Peoples R china and India but we tried to give a hierarchical result on this particular field.

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