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Abstract

Purpose: The selection of an effective library software plays an important role not only for students, academic staff, and the library staff but it also helps an institution by having the library management system more centralized. Therefore, the aim of this study is to develop a Multiple-Criteria Decision Analysis (MCDA) cause and effect factor model for the implementation of the Greenstone digital library (GSDL) software.

Methodology: A thorough review of the literature is conducted to develop an initial list of the appropriate evaluation factors that play a significant role in the implementation of GSDL software. The data was collected from a domain of experts in the library sciences field. A combined approach of Delphi-DEMATEL methods is employed for the definition of these factors and to construct an MCDA cause-effect model which represent their relationships.

Findings: The DEMATEL analysis resulted in the division of all factors into two groups, i.e., causes and effects. The results show that content management, having a user-friendly interface and usability, information search and retrieval, authentication and authorization fall into the cause group. These factors directly affect the remaining factors. Content acquisition, classification, access, control and privacy management, plus metadata submission and support fall into the effect group. The research findings can help library professionals to make effective decisions to facilitate the successful implementation of GSDL software in a library and the enhancement of library technology.

Practical implications: The results of this study can be useful for library professionals and decision-makers to select the most appropriate software for the implementation of library technology. The study analysis shows that for GSDL, having a user-friendly interface and usability, information search and retrieval plus authentication, and authorization factors have

seven positive relationships with other factors. Secondly, content management and classification have six relationships with other factors. Thirdly, access control plus privacy and management have two relationships. Content acquisition has only one relationship with other factors. It is recommended that the user-friendly interface and usability, information search and retrieval, as well as authentication and authorization should be the initial areas of focus if GSDL is to be implemented successfully in digital libraries.

Originality/value: The proposed MCDA cause-effect model can be useful for library professionals or decision-makers in the context of selecting software to be implemented in a library and to minimize implementation costs.

Keywords: Technology enhancement, MCDA, Digital library software, Greenstone, DEMATEL, Cause-Effect, Delphi

Paper type Research paper

1. Introduction

No one can avoid the impact of automation in all types of businesses and institutions, especially the library sciences, where the automation can provide a centralized management system. But which software should be implemented for technology enhancement so that it would help the institution not only to get all stakeholder satisfaction but also to minimize the cost of implementation for the automation of the library? Library software enables the retention of activities such as circulation, circulation history, administration, cataloguing, reporting, and patron records. Therefore, the selection of a good software plays an important role for technology assessment, not only for the library staff, but also for the students and academic staff of an institution (Robbins et al., 2006; Wu et al., 2013; Rosa et al., 2017). Therefore, it is a crucial task with many things having to be taken into consideration during the process of adopting any new software in a library (Cabrerizo et al., 2010; Wu et al., 2013; Xi et al., 2018). This study is related to finding those factors that play a significant role for the implementation of the Greenstone Digital Library (GSDL) software in a library. Working in a systematic manner, the first query in the process of software selection is *to identify the problems that we are trying to solve*. Typically, this doesn't happen because the problem statement is simply too obscure. For any digital library project, the problem statements are often constructed along the lines of a mission statement, and they should provide access for intellectual output to the user community (Wu et al., 2013; Xi et al., 2018).

The selection of software is never a simple process. It is the responsibility of the library staff to provide the best services to the institution's stakeholders (e.g., staff, students, etc.). Therefore, they should always try to make the library process as simple and as smooth as possible. There are many challenges (e.g., content, management support, etc.) in the digital library process that cannot be ignored. But among these challenges, content, users, quality, policies, technology, functionality, and personnel are all of paramount importance for the

implementation of any software in a library (Anunobi and Ezeani, 2011; Xi et al., 2018). To ensure the success of effective library services at an institution, efforts have to be implemented as steppingstones and must prove to be worthwhile (Anunobi and Ezeani, 2011). Therefore, the implementation of effective software in a library is extremely important for an institution. Greenstone is not an individual piece of software; it is a suite of programs to set up a digital library. It is one of the leading free and open-source software (FOSS) packages. Such multilingual software provides a way of constructing, organizing, presenting, and disseminating the collection in the form of a searchable, metadata-driven digital library. Greenstone software is compatible with all operating systems, and the plug-ins provide a broad variety of document types including plain text, Microsoft Word, PDF documents, Excel spreadsheets, HTML pages, Power Point, pictures, videos, MARC, and other records. In the new version of Greenstone software, the new plug-ins feature allows a simple search, an advanced search, full-text searching, and the browsing of non-textual material. It can be linked to text material or to descriptions such as for a figure or image. Unicode is a standard scheme for expressing the characters used for the different languages in Greenstone. It manages the user interface in a multilingual system. The documents in any language can be processed and presented (Robbins et al., 2006; Kaushik et al., 2015).

Given the above-mentioned advantages, Greenstone is an open source software, is accessible freely, and can be modified as per the requirements of the institution. It also facilitates a set of values in which the source of the code is available to all for customization or modification. Generally, computer users do not even see the different parts of a software package, e.g., a source code through which computer programmers can change a program to improve its features. In open source, the source code is provided to others for learning, altering, or sharing with other authors. The users have to accept the terms of the license for proprietary software. FOSS users also have to accept different legal terms from the proprietary software.

1.1 Research gaps

From the literature review in section 2, it is clear that many researchers have put much of their efforts toward studying the digital library. However, the current literature is limited in the context of technology enhancement especially in the term of adopting new software in a library. There are only a few structured studies on the evaluation of software and decision-making approaches in the field of the academic library. No study has been conducted related to adoption of Greenstone software in the digital library that have answered the following research questions:

RQ1: What are the factors that affect the adoption of Greenstone software and which require a deeper understanding in their implementation?

RQ2: What are the cause and effect inter-relationships among the identified factors that play a significant role in the implementation of GSDL software in the digital library?

RQ3: How can the identification of these inter-relationships help decision makers to formulate strategies toward the implementation of GSDL software in the digital library?

The motivation for conducting this study is to answer the above-mentioned questions while filling in the present literature gap. Therefore, the following objectives are set:

1. To find out those factors that play a significant role in the implementation of Greenstone in the digital library.
2. To establish the priority rank and cause-effect inter-relationships among them.
3. To identify the important causal factors so that an institute can make an action plan to focus on them first.

To achieve the above-mentioned objectives, a two-phase approach has been used. In the first phase, after identifying factors from the literature review and expert opinions, the Delphi method is used to finalize a list of factors. To analyze the inter-relationships among these factors, decision making trail and evaluation laboratory (DEMATEL), a MCDM approach, is

employed. DEMATEL has been used to manage and solve many global problems by considering expert views in political, economic, and the scientific spheres (Kaushik and Somvir, 2015; Kumar and Dash, 2017). This is the most widely used technique found in the current literature to solve complex problems (Kumar and Dash, 2017; Kumar et al., 2017; Kumar et al., 2018; Hu et al., 2018a, 2018b; Hatefi and Tamošaitienė, 2019). Based on a diagram of the influencing network relationship map (INRM), a cause and effect relationship analysis can be drawn up for the factors involved. Hence this study contributes to the existing library science literature in the following ways:

- The study contributes to existing knowledge of library science literature and helps decision makers to understand the most significant factors that are playing an important role in the adoption of any software in the digital library which further would help in the context of technology enhancement the library.
- The outcomes of this study provide important insights for decision makers to business develop strategies for the implementation of GSDL software in the digital library so that they can not only minimize their cost of implementation but also achieve the satisfaction of library stakeholders.
- There are a lot of MCDM methods available in the current literature with Delphi and DEMATEL methods widely applied in decision making methods (Kumar and Dash, 2017; Kumar et al., 2018; Mangla et al., 2018). But in the library science domain, a combined approach of these techniques has not been used. The inter-relationships among the factors as well as a cause-effect model based on the factors arising from GSDL have now been identified through this study.

The literature review is given in section 2 of this study. The methods and methodology are explained in section 3. The proposed research framework is presented in section 4. The

implementation and recommendations of this study are detailed in section 5. In the last section, the conclusions are explained.

2. Literature review

In this section, we introduce the concept of the digital library, identify the factors involved, and look at the application of multi-criteria decision making (MCDM) methods in the library sciences.

2.1 The concept of a digital library

The presence of FOSS in the digital library (DL) software category, i.e., DSpace, Eprint, and GSDL, and in ILMS category, Koha and Newgenlib, was examined by Hanumappa (2014). The migration or adoption of FOSS among Indian libraries has drawn considerable interest from institutions recently as the benefits to the library become better known. But there are barriers to the implementation of FOSS. Rafiq et al. (2018) studied the barriers to digitalization in the central university libraries of Pakistan. The mixed methods of quantitative and qualitative research were used for their study. The results showed that in the university libraries of Pakistan, the major and core barriers to digital initiatives are a lack of financial resources, a shortage of technological resources and infrastructure, the absence of a digitization policy, and a lack of skills and knowledgeable human resources for implementing these initiatives. Student intention to use electronic library services is dependent on effort expectancy, performance expectancy, and social influences, while student user behavior is dependent on facilities and intention to use; these were indicated by the hypotheses of the empirical examination of the model. For younger undergraduate and social science students, the effect of performance expectancy and user behavior was significant, while effort expectancy was significant for older and applied discipline students (Awwad, 2015).

Han (2004) made a study of digital content management systems by analyzing Greenstone, Fedpora, and Dspace on the basis of preservation, metadata, access, and features on the basis of the needs of the University of Arizona Library. Wales (2005) made a case study on content management at the Open University, United Kingdom. The author found that there is a complex design and implementation aspect due to the nature of the subject guide. He also examined reasons for not adopting the content management system. Seadle (2006) described the content management system and studied the object-oriented DBMS, user needs, implementation, and inter-operability. The web presence in a library requires a highly efficient level of management. Tien et al. (2006) found that for a large-scale digital archive to be implemented successfully, it is necessary to include various domains of the natural sciences in the study of unified knowledge-based content management of a digital archive in museums.

Cabrerizo et al. (2015) made a study on the decision support system to develop quality management in an academic digital library. For the satisfaction of users, an academic digital library should provide good services. Several rules are composed in the decision support system to generate the recommendation according to objective and subjective criteria. Gerogiannis et al. (2015) suggested a practical approach for the improvement of software selection in small- and medium-sized enterprises. The authors presented a fuzzy linguistic approach for the evaluation of human resources and the selection of software in the context of the SPRINT SMEs project. They noted that the selection and allocation of human resources in software development are very difficult tasks; the authors provide a practical framework that contributes to and supports management in these tasks.

The business processes of any organization are influenced by the evaluation and selection of open source software in the learning management system. This study has a three-fold approach, i.e., published papers, criteria of evaluation, and the abilities of the selection method. The authors have provided a list of FOSS LMS packages, the gaps of evaluation criteria, and

the use of MCDM techniques for evaluation with FOSS as the recommended selection (Abdullateef et al., 2016). To define the most appropriate alternatives, keeping in mind a firm's goals, the fuzzy TOPSIS model can be used. Efe (2016) used an integrated method of fuzzy AHP and TOPSIS for the selection of an ERP system. According to the author, the degree of importance of each decision affects the final decision. The results of this study provide a robust solution for the selection of ERP and indicate that the methodology used by the author allows for a decrease in information loss in group decision making while making allowances for uncertainty. The failure or success of any business intelligence project depends upon the selection of the right software. Hanine et al. (2016) used two multi-criteria techniques for an analysis of the structure of the ETL software selection problem and TOPSIS for calculating alternative ratings.

Ravikumar and Ramanan (2014) conducted a study for the comparison of GSDL and Dspace on the basis of experiences from digital library initiatives at the Eastern University of Sri Lanka. The authors compared the software not only for its technical features and workflow, but also for its authentication basis and the usefulness of distributed work. The correct selection of software to fulfill the organizational and project needs can be a problem due to the availability of numerous pieces of software with different features and functions. TOPSIS4BIM, a web-based decision support system, has been developed. Nursal et al. (2015) used the latest technology, web 2.0 and cloud technology, to present the evaluation of the proposed decision support system. Gokumas and Lazarinis (2015) made a study to evaluate the OSS for collection management and digital libraries. Different utilization scenarios were proposed by the authors after the evaluation of tools based on technology, time, and staff constraints. A number of usage scenarios were analyzed on the basis of the results obtained from the experiences of users. For various types of establishment projects based on OSS, the study can help in making the correct selection.

Park and Sinn (2016) evaluated six open-source software packages for participatory digital archives. The authors analyzed the OSS based on the identified functions and requirements of digital archives in a digital system on the basis of social memory and how it can be stored and used.

Nurmikko-Fuller et al. (2016) described the main features of constituent datasets, describing the conversion workflow while performing a comparative analysis of InConcert. With a focus on exposing the legacy datasets to linked data, the study provided practical recommendations for future efforts.

Proper strategies and tools are required for data preservation. Rosa et al. (2017) focused their study on state-of-the-art methods in OSS solutions for digital preservation. A survey was carried out on 11 open-source projects for digital preservation based on seven criteria. The standards and protocols relevant to digital preservation were also surveyed in the study. Open-source software was studied by Rao and Kumar (2017), with special reference made to Koha and Dspace for digital libraries. The study highlighted the influence of libraries using digital resources in the context of information retrieval by internet users. Various features of the OSS for content management were also highlighted by the authors, including automation, the digital library, and the institutional repository.

A new level of flexibility and inter-operability is now available due to the use of semantic web technologies in digital libraries. Based on semantic web technology, Pandey and Panda (2014) provided a semantic solution for digital libraries. The authors provided the emerging concept of the social semantic digital library using semantic web technologies. Cunningham et al. (2016) investigated the assumption that the software is equally well suited for use by any user, regardless of gender, in the context of digital libraries. The authors analyzed a significant digital library construction through GSDL using the gender mag tool kit. According to Choi and Pruett (2015), the specific motivation and characteristics of those developers participating

in library open source software projects has not been examined. The authors conducted an empirical study on the characteristics and motivation of library open source software (LOSS) developers. In the study, an online survey was completed of 126 LOSS developers to explore their characteristics and motivations. A high level of intrinsic values, higher diversity in gender, higher levels of formal education, previous library related work experience, and a strong library ethos were indicated by the results.

Paz and Pow-sang (2016) carried out a systematic review of usability evaluation methods for the software development process. The authors identified the current trends that are taken up for usability evaluation methods. Two-hundred and fifteen studies were selected out of 1169 identified for the review by the authors. Okhovati et al. (2016) looked at the usability of the websites of central libraries of medical universities in Iran. To evaluate the usability of websites, the authors used the heuristic evaluation method in their study.

2.2 The identification of factors

To identify the relevant factors that play a significant role in the implementation of Greenstone in a digital library, an investigation of the existing literature has been carried out and various databases such as Science Direct, Scopus, EBSCO, Taylor and Francis, Emerald, and Wiley were filtered. An extensive literature is available related to digital libraries, but with respect to our study objectives, there is less literature available for review. Following the literature review and discussions with industry experts, 12 factors were initially identified. But after conducting a first-phase study, only eight of the most important factors were finalized for further analysis (more information about the first-phase study is given in Section 4.1.). The final selected factors (Table I) are described as follows.

2.2.1 Content acquisition (F1). Content is the most important aspect for digital libraries. The quality of content used for a digital library is crucial, although it is acknowledged that a

great deal of material is also available freely on the web. To share the common knowledge concept by integrating classification hierarchy-based browsing interfaces, we can allow users to access knowledge content (Tien-Yu et al., 2006).

2.2.2 Content management (F2). This includes selection and acquisition, indexing, storage, retrieval, maintenance, and rights management. These factors are identified from the end users of the digital library. The software should be able to handle different communities of users. Across various subject disciplines, content management can have different meanings (Han, 2004). According to Seadle, content management is a way in which large amounts of web-based information can be managed (Seadle, 2006).

2.2.3 User friendly interface and usability (F3). The flexibility of customizing the interface according to the needs for multilingual support and other items is covered in the user interface. The user can choose the specific language for the DL's interface that has multilingual access. To work on specific goals with effectiveness, efficiency, and satisfaction for specific users/libraries, the software should be suitable. For the success of any technical product, the most important factor is usability, which is the capability of the software to understand, be liked, and be attractive when used for specific purposes (Paz and Pow-sang, 2016).

2.2.4 Classification (F4). To collect related content into specific groups and according to the users, classification and indexing schemes are necessary. Classification is a very powerful mechanism for differentiating information resources at both broad and specific levels. To support information seeking within a collection and across a collection, the software used for a digital library should support many levels of representation (Lopez et al., 2004).

2.2.5 Information search and retrieval (F5). The retrieval of information should be quick; it is important to users who are selecting relevant information. The search interface should search across databases while modifying the query. The system should return good matches

according to the user's query that contains the specific keywords describing the information needed (Carpineto et al., 2012).

2.2.6 Access control, privacy, and management (F6). The software should be able to store all of the information related to users and their roles. All features should be available in the software related to its administration, including those items that concern digital authentication and access management (Dixon, 2008).

2.2.7 Authentication and authorization (F7). The software used for a digital library should be capable of preventing malicious use and ensuring the privacy of its digital content. To control the access of users and facilitate registered users through portal authentication, authorization technology is used (Shoeb, 2010).

2.2.8 Metadata submission and support (F8). An information resource or access to information source is described by an element of the metadata (Cathro, 1997). Metadata is a kind of fellow traveler with data; it is not fully-fledged data. Accessibility by matching users' needs and preferences with available solutions is promoted by an integral component; this new generation approach is metadata (Beyene, 2017).

<insert Table I about here>

2.3 The application of MCDM in library sciences

The speedy development of information technology is impacting Indian libraries as the automation of Indian libraries is progressing very fast (Ravikumar and Ramanan, 2015; Rao and Kumar, 2016). Therefore, the adoption of appropriate software is a very important part of the Indian library. The question is which software should be implemented so that it will help decision-makers not only to minimize the implementation cost of software but also to obtain the satisfaction of all stakeholders. The implementation of any software in a library involves many factors to be addressed in order that an effective adoption can be achieved. Thus, the

adoption of appropriate software in the library is a multi-criteria problem that can be handled by using MCDM methods. Therefore, it is a multi-criteria problem and to select the best criterion is the main goal. Multi-criteria decision-making (MCDM) methods have the capability of selecting the best one of many that are widely used and acknowledged in the present literature (Efe, 2016; Hanine et al., 2016; Kumar and Dash, 2017; Kumar et al., 2018; Ferreira et al., 2019; Mavi et al., 2019; Gonçalves et al., 2019; Barroso et al., 2019; Kaklauskas et al., 2011; Fonseca et al., 2018; Pires et al., 2018; Yazdani et al., 2019). The details of MCDM methods in use in the library sciences are provided in Table II.

<insert Table II about here>

As per Table II, there are many MCDM methods have been used by the researchers in the library sciences but these applications are still limited, even if they are available in the context of Indian library where massive automation is ongoing. There is no discussion is available in literature where the researchers discuss constructing a cause-effect factor model for the implementation of Greenstone digital library software in the Indian context.

3. Method

There are two main phases in the research framework for this study. The first phase is related to the selection of appropriate factors from the literature review, and the Delphi method is used for finalization. In the second phase, the cause-effect model is developed with the help of the DEMATEL approach.

In the following section, the methods used in the study are briefly described.

3.1 The Delphi method

When many options are available to experts for evaluation, they may get confused while selecting the best of them (Hsu et al., 2010). In what can become a tedious job for evaluating the options, an effective approach must be adopted. The Delphi method has the capability of

performing this tedious job efficiently (Hsu et al., 2010; Kumar et al., 2017). The group decisions recorded in the Delphi method are different from other methods in terms of the stability of the replies and the feedback; all researchers face the same common problems, i.e., the stability of the replies and the feedback system (Kumar et al., 2017).

3.2 DEMATEL

To analyze the inter-relationships among the factors, DEMATEL is a very powerful method (Chen, 2016; Kumar et al., 2018; Chen et al., 2018). The DEMATEL literature (Kumar and Dash, 2016; Kumar et al., 2017; Kumar et al., 2018; Mangla et al., 2018; Song et al., 2020) shows that it is regarded as one of the best techniques for handling important and causal relationships among factors. Fontela and Gabus employed the DEMATEL technique at the end of 1971. By successfully showing how to take up experts' views to solve many global problems in scientific, political, and economic fields, this technique is now widely used (Falatoonitoosi et al., 2012; Kaushik and Somvir, 2015; Kumar and Dash, 2017; Kumar et al., 2018; Mangla et al., 2018). DEMATEL is a well-established method for evaluating cause and effect inter-relationships among factors, and it is the most widely used technique seen in current literature for solving complex problems (Kumar and Dash, 2017; Kumar et al., 2017; Kumar et al., 2018; Hu et al., 2018a, 2018b; Hatefi and Tamošaitienė, 2019). Based on a diagram of the influencing network relationship map (INRM), an analysis of the cause and effect relationships can be drawn up for the factors involved. Thus, because of robust conceptual foundations and wide acceptability in literature, the DEMATEL technique has been selected to achieve the objectives of this study.

There are several mathematical steps explained below in the DEMATEL technique.

Step 1. A scale from 0 to 4 is used to evaluate the relationships among the *factors* ($i, j = 1,\ldots n$). Using Eq. (1), the average is calculated:

$$A = \frac{1}{p}\sum_{K=1}^{p} x_{ij}^{k}, \quad i, j = 1, 2, \ldots, n \tag{1}$$

In Eq. (1) p is the number of experts.

Step 2. In this step, the D normalization matrix is calculated from Eq. (2) and Eq. (3).

$$D = m \times A \tag{2}$$

where

$$m = \min\left(\frac{1}{\max_i\left(\sum_{i=1}^{n} a_{ij}\right)}, \frac{1}{\max_j\left(\sum_{j=1}^{n} a_{ij}\right)}\right), i,j = 1,\ldots n \tag{3}$$

Step 3. The total relation matrix is calculated by utilizing Eq. (4).

$$T = D(I - D)^{-1} \tag{4}$$

The total of rows and columns of the T matrix is calculated by using Eq. (5) and Eq. (6).

$$r = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{5}$$

$$c = [c_i]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \tag{6}$$

Step 4. Eq. (7) is used to avoid minor effects.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \tag{7}$$

4. Application of the proposed framework

4.1 Phase I: Finalizing factors for evaluation

Through the literature review, a set of important factors for evaluating the GSDL are identified.

The Delphi method is applied in the preliminary set of factors to identify those that are relevant;

these are depicted in Table II. To collect the experts' opinions, a questionnaire was designed (shown in Appendix, Table AI). With a scale from 0 (no influence) to 4 (4 = high influence), a snowball sampling was used. A number of five to 20 experts is an acceptable size (Gumus, 2009); the efficiency of group decision making is affected by the group size (Anderson et al., 2001). Here, 12 experts, all of whom have more than 10 years of experience working in digital libraries, were involved in the evaluation. The relevance of factors is also affected by the threshold value; a higher threshold of factors affects the research. In this study, the threshold value to identify the prominent factors is 3.85. The results of Delphi (Table III) show that the important value of factors falls in the range of 3.85 to 4.15, with eight factors finalized for the evaluation.

<insert Table III about here>

4.2 Phase II: Constructing a cause-effect factor model

From the preliminary screening phase, eight factors were selected and a questionnaire prepared (see Appendix, Table AII). The data of 12 experts were collected, and they are shown as follows.

E1

0	4	3	3	2	2	1	4
4	0	3	3	4	2	3	1
4	4	0	4	3	4	4	4
2	3	3	0	4	3	4	2
4	4	3	4	0	4	3	2
3	2	2	3	4	0	2	1
4	3	4	2	3	2	0	3
1	4	1	3	2	1	3	0

E2

0	2	3	1	3	2	1	1
2	0	3	3	4	3	3	3
3	2	0	4	0	2	2	2
1	1	3	0	4	3	4	1
4	3	3	4	0	4	3	2
2	1	2	3	4	0	2	1
1	2	4	4	3	2	0	3
3	1	3	3	2	1	3	0

E3

0	3	1	2	2	3	2	1
3	0	3	2	2	2	4	2
1	1	0	3	4	4	1	1
2	3	3	0	2	2	3	2
1	2	2	4	0	1	3	2
1	0	3	4	1	0	2	3
2	1	3	1	3	4	0	4
3	4	1	2	2	3	4	0

E4

0	1	2	3	1	0	3	1
3	0	3	4	3	4	0	2
2	2	0	4	4	2	4	2
1	4	1	0	3	2	1	3
3	1	3	3	0	1	3	3
3	2	1	4	1	0	2	2
3	2	3	3	3	3	0	1
1	2	3	3	1	2	4	0

E5

0	2	4	3	3	1	1	3
1	0	3	4	2	3	4	0
3	4	0	4	4	4	4	4
1	4	4	0	2	3	4	4
2	2	2	2	0	3	4	4
1	3	3	3	3	0	4	4
3	4	4	4	4	4	0	2
4	3	3	2	4	1	2	0

E6

0	3	4	3	2	1	4	1
3	0	3	3	4	2	3	1
4	4	0	4	4	4	4	2
2	3	3	0	4	3	4	4
4	4	3	4	0	4	3	2
3	2	2	3	4	0	2	4
4	3	4	2	3	2	0	3
1	4	1	3	2	1	3	0

E7

0	4	2	3	0	2	2	1
1	0	3	3	4	2	3	2
2	2	0	4	4	4	4	4
2	1	3	0	4	3	4	2
4	1	3	1	0	4	3	2
3	2	2	3	4	0	2	1
4	3	4	0	3	2	0	3
4	2	1	0	2	1	3	0

E8

0	4	4	4	4	4	4	4
3	0	3	3	4	2	3	4
4	4	0	4	4	4	4	4
2	3	3	0	4	3	4	4
4	4	3	4	0	4	3	2
3	2	2	3	4	0	2	1
4	3	4	2	3	2	0	3
1	4	1	3	2	1	3	0

E9

0	2	2	1	2	3	4	0
3	0	3	3	1	2	3	2
4	4	0	4	2	4	4	2
3	3	3	0	3	3	4	1
3	4	3	4	0	4	3	0
3	2	2	3	4	0	2	1
4	3	4	2	3	2	0	4
4	4	1	3	2	1	3	0

E10

0	3	4	4	2	4	0	3
3	0	3	3	4	2	3	2
4	4	0	1	1	1	1	2
2	1	1	0	4	3	4	0
4	2	3	4	0	4	3	2
3	2	2	3	4	0	2	1
4	2	4	2	3	2	0	3
1	0	0	3	2	1	3	0

E11

0	3	2	1	0	2	1	3
3	0	4	3	2	2	3	1
2	4	0	4	3	4	4	1
4	3	3	0	4	3	0	1
2	4	3	4	0	4	3	2
2	2	2	3	4	0	2	1
4	3	4	2	3	2	0	0
1	4	1	3	2	1	3	0

E12

0	2	1	3	2	4	2	2
3	0	3	1	1	2	3	4
4	2	0	4	2	4	4	3
2	1	3	0	1	3	4	4
4	4	3	1	0	4	3	2
3	1	2	2	4	0	4	1
4	3	4	1	4	4	0	3
1	0	1	2	3	2	1	0

By using Eq. (1), the average matrix is calculated (Table IV).

<insert Table IV about here>

The *D* matrix is calculated using Eq. (2) and Eq. (3):

0.0000	0.1245	0.1208	0.1170	0.0868	0.1057	0.0943	0.0906
0.1208	0.0000	0.1396	0.1321	0.1321	0.1057	0.1321	0.0906
0.1396	0.1396	0.0000	0.1660	0.1321	0.1547	0.1509	0.1170
0.0906	0.1132	0.1245	0.0000	0.1472	0.1283	0.1509	0.1057
0.1472	0.1321	0.1283	0.1472	0.0000	0.1547	0.1396	0.0943
0.1132	0.0792	0.0943	0.1396	0.1547	0.0000	0.1057	0.0792
0.1547	0.1208	0.1736	0.0943	0.1434	0.1170	0.0000	0.1208
0.0943	0.1208	0.0642	0.1132	0.0981	0.0604	0.1321	0.0000

Total relationship matrix (*T*) is computed:

Matrix T	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.5521	0.6435	0.6553	0.6832	0.6525	0.5321	0.5626	0.7393*
F2	0.7416*	0.6109	0.7514*	0.7792*	0.7720*	0.7117*	0.7768*	0.6063
F3	0.8452*	0.8190*	0.7170*	0.8992*	0.8658*	0.8366*	0.8847*	0.7014
F4	0.7225*	0.7163*	0.7435*	0.6668	0.7896*	0.7338*	0.7966*	0.6222
F5	0.8156*	0.7781*	0.7952*	0.8471*	0.7116*	0.8023*	0.8376*	0.6531
F6	0.6747	0.6265	0.6546	0.7223*	0.7281*	0.5581	0.6927	0.5465
F7	0.8129*	0.7616*	0.8201*	0.7960*	0.8245*	0.7626*	0.6050	0.7167*
F8	0.6001	0.6036	0.5727	0.6368	0.6205	0.5558	0.6524	0.4247

By using Eq. (6) and Eq. (7), *T* is calculated; the results are shown in Table V.

<insert Table V about here>

Eq. (7) is used to calculate α; this is 0.7092. Those values $>\alpha$ were retained to construct the cause-effect model based on the procedure described in section 3.2; these values are marked by a star (*) in the *T* matrix. The causal maps are shown in Figure 1 and Figure 2.

<insert Figure 1 about here>

<insert Figure 2 about here>

The user-friendly interface (F3) has the largest ($r+c$) value = 12.279; metadata submission and support (F8) has the smallest ($r+c$) value = 9.427. Regarding ($r+c$) values, the prioritization of importance is F3 > F5 > F7 > F4 > F2 > F6 > F1 > F8. The user friendly interface is the most important and metadata submission and support is the least important.

Based on r-c values, the eight factors were divided into (i) the cause group and (ii) the effect group. The factors of content management (F2), user friendly interface (F3), information

search and retrieval (F5), plus authentication and authorization (F7) are classified in the cause group, having (r-c) values of 0.191, 0.859, 0.276, and 0.141, respectively. The factors content acquisition (F1), classification (F4), access control, privacy and management (F6), as well as metadata submission and support (F8) are categorized in the effect group, with (r-c) values of -0.744, -0.239, -0.390, and -0.094, respectively. Content acquisition (F1) has an influence relationship with F8; content management (F2) has six influencing relationships with F1, F3, F4, F5, F6, and F7, and it is a causal factor. This indicates that content management is a significant factor in the implementation of GSDL in a digital library.

User friendly interface and usability (F3) has seven influencing relationships; these are F1, F2, F4, F5, F6, and F7, which indicates that user friendly interface and usability are key factors for a software that is to be implemented, and these influenced the other factors as well. The factor classification (F4) has six influencing relationships with F1, F2, F3, F5, F6, and F7.

The causal factor named information search and retrieval (F5) has seven influencing relationships with F1, F2, F3, F4, F6, F7, and itself. Access control, privacy, and management (F6) has two influencing relationships with classification (F4) as well as information search and retrieval (F5). The factor authentication and authorization (F7) has seven influencing relationships with F1, F2, F3, F4, F5, F6, and F8.

The values of t_{ij} in Table IV, which are > α (0.7092), were highlighted and shown as t_{ij}*, presenting the interaction between perspectives, e.g., the value of t_{18} (0.7393*) > α (0.7092). The cause-effect model of the eight perspectives is constructed as shown in Figure 1. The construction of the inter-relationship map is shown in Figure 2.

5. Theoretical and practical implications

In today's world, digitalization is becoming more powerful and serviceable. The use of digital objects and materials is increasing very rapidly. The accessibility of information is also

becoming easier due to digitalization. In this work, we have identified the factors of GSDL to be implemented for a digital library as well as their cause and effect groups and influence they have on each other. This study contributes to the available literature both theoretically and practically. The study has established the factors that are the most and least important and their influence theoretically. The results of the study could help practitioners in making a more informed choice when introducing new software. The theoretical contributions of this study are twofold. First, the most important factors that play a critical role in the implementation of new software in the library are identified through a literature review and expert inputs. Second, the Delphi method is used for finalization of these factors with a cause-effect model developed by using a DEMATEL technique.

From a practical perspective, the study has shown the priority of the identified factors and their inter-relationships, i.e., their cause and effect relationships. This work clearly shows that user friendly interface and usability, information search and retrieval, plus authentication and authorization are the most important factors; these have seven positive relationships with other factors. Content management and classification factors are the second most important; these have six positive relationships with other factors. Access control, privacy, and management has influencing relationships with classification, information search, and retrieval in the effect group. From a management point of view, if we are going to implement the software GSDL successfully, we must focus on user friendly interface and usability, information search, and retrieval, authentication and authorization and content management as causal factors with classification as an effect.

Because of the usability of GSLS, many institutions have implemented GSDL. Some examples are Universidad Católica Argentina, The Lincoln Archive Digital Projects of National Archives of the United States, the Oxford Digital Library (Oxford University), and the MOST Digital Library (UNESCO).

The American University Library (AU Digital Research Library Archive), Catholic University of America (CUA Digital Collection), Gallaudet University Archive and Library, University of the District of Columbia (UDC LRD Digital Collection) under Washington Research Library Consortium Special Library Collections have all been involved in successful projects after implementing GSDL. With these examples, we see that because of access usability, many institutes have implemented GSDL. The findings of this study should help library professionals and decision-makers implement GSDL in Indian libraries with a focus on the important identified factors during the period of implementation.

6. Concluding remarks

For business development point of view, different services can be provided in the best possible manner to users by evaluating them through different methods. The main objective of this work is to develop a cause-effect factor model for the implementation of Greenstone digital library (GSDL) software and further would help the decision-makers for technology enhancement in the library science domain. To achieve the study objectives, the entire study was conducted in two phases. In the first phase, the most important factors are identified through a literature review and expert inputs. After identification of the factors, a Delphi method is used for finalization of these factors. To construct the cause-effect model, a DEMATEL method is used. This method helps us to understand the cause and effect group factors. As per the analysis, the factor user-friendly interface and usability, information search and retrieval, plus authentication and authorization are the most important factors; these have seven positive relationships with other factors.

Content management and classification are the second most important factors, having six relationships with other factors. It is recommended that during the implementation of GSDL, there should be a focus on user friendly interface and usability, information search and

retrieval, and authentication and authorization, plus content management as causal factors. Second, classification, access control, privacy management, content acquisition, and metadata submission and support should be regarded as effective factors.

There are several limitations of this study. The first limitation is that this study is conducted only on GSDL, the popular digital library software, but in future research study other software can be considered and a comparative analysis would be possible. The second limitation is that the analysis is based on the data that was collected from library professionals. Therefore, an empirical research is possible in future to make it more generalized. In the field of library science, as perspectives change and technology advances are happening very fast, a proper selection of an approach is a very useful for making decisions in the management of libraries and the selection of different pieces of software for implementation in various fields. Therefore, research can be conducted to understand the weight of each factor by using other MCDM methods, for instance, BWM, VIKOR, etc.

References

Abdullateef, B.N., Elias, N.F., Mohamed, H., Zaidan, A.A. and Zaidan, B.B. (2016), "An evaluation and selection problems of OSS - LMS packages", *SpringerPlus,* Vol. 5 No. 248.

Ackermann, E.G. (2003), "Usage and usability assessment: library practices and concerns", *Portal: Library and The Academy*, Vol. 3 No. 1, pp. 163-164.

Anderson, T., Liam, R., Garrison, D.R. and Archer, W. (2001), "Assessing teacher presence in a computer conferencing context", *Journal of the Asynchronous Learning Network*, Vol. 5 No. 2, pp. 1-17.

Anunobi, C.V. and Ezeani, M.I. (2011), "Digital library development in a university: Challenges and prospects", *Library H*, Vol. 29 No. 2, pp. 373-386.

Awwad, Mohammad Sulieman, S.M.A.-M. (2015), "Electronic library services acceptance and use, an empirical validation of unified theory of acceptance and use of technology", *The Electronic Library*, Vol. 33 No. 6, pp. 1100-1120.

Barroso, R.M.R., Ferreira, F.A.F., Meidutė-Kavaliauskienė, I., Banaitienė, N., Falcão, P.F. and Rosa, Á.A. (2019), "Analyzing the determinants of e-commerce in small and medium-sized enterprises: a cognition-driven framework", *Technological and Economic Development of Economy*, Vol. 25 No 3, pp. 496-518.

Bellido, L., Villagrá, V. and Mateos, V. (2010), "Federated authentication and authorization for reusable learning objects", in *2010 IEEE Education Engineering Conference, EDUCON* 2010, pp. 1071-1074.

Beyene, W.M. (2017), "Metadata and universal access in digital library environments", *Library Hi Tech*, Vol. 35 No. 2, pp. 210-221.

Boiko, B. (2002), *Content Management Bible*, Hungry Minds, New York.

Bowen, J. (2008), "Metadata to support next-generation library resource discovery: Lessons from the eXtensible catalog, Phase 1", *Information Technology and Libraries*, Vol. 2, pp. 6-19.

Cabrerizo, F.J., López-Gijón, J., Ruiz, A.A. and Herrera-Viedma, E. (2010), "A model based on fuzzy linguistic information to evaluate the quality of digital libraries", *International Journal of Information Technology & Decision Making*, Vol. 9 No. 3, pp. 455-472.

Cabrerizo, F.J., Morente-Molinera, J.A., Javier, I., López-Gijón, J., Herrera-Viedma, E., (2015). "A decision support system to develop a quality management in academic digital libraries", *Information Sciences*, Vol. 323, pp. 45-58.

Carpineto, C. and Romano, G. (2012), "A survey of automatic query expansion in information retrieval", *ACM Computing Surveys*, Vol. 44 No. 1, pp. 1-50.

Cathro, W. (1997), "Matching discovery and recovery", in *Proceedings of the Seminar on Standards,* Australia.

Chen, C.-Y., Tzeng, G.-H. and Huang, J.-J. (2018), "Generalized DEMATEL technique with centrality measurements", *Technological and Economic Development of Economy*, Vol. 24 No. 2, pp. 600-614.

Chen, Y.T. (2016), "Applying the DEMATEL approach to identify the focus of library service quality: A case study of a Taiwanese academic library", *The Electronic Library*, Vol. 34 No. 2, pp. 315-331.

Choi, N. and Pruett, J.A. (2015), "The characteristics and motivations of library open source software developers: An empirical study", *Library and Information Science Research*, Vol. 37 No. 2, pp. 109-117.

Chowdhury, S., Landoni, M. and Gibb, F. (2006), "Usability and impact of digital libraries: A review", *Online Information Review*, Vol. 30 No. 6, pp. 656-680.

Colombo, P. and Ferrari, E. (2015), "Privacy aware access control for big data: A research roadmap", *Big Data Research*, Vol. 2 No. 4, pp. 145-154.

Cunkun, C., Siqin, S. and Fengtan, H. (2014), "Subject service evaluation model study in university library based on AHP", *Journal of Academic Libraries*, Vol. 6, 016.

Cunningham, S. J., Hinze, A. and Nichols, D.M. (2016), "Supporting gender-neutral digital library creation: a case study using the GenderMag toolkit", in *International Conference on Asian Digital Libraries*, Springer, Cham, pp. 45–50.

Ding, Y., Chowdhury, G.G. and Foo, S. (2000), "Incorporating the results of co-word analyses to increase search variety for information retrieval", *Journal of Information Science*, Vol. 26 No. 6, pp. 429-451.

Dixon, P. (2008), "Ethical issues implicit in library authentication and access management: Risks and best practices", *Journal of Library Administration*, Vol. 47 No. 3-4, pp. 141-162.

Efe, B. (2015), "An integrated fuzzy multi criteria group decision making approach for ERP system selection", *Applied Soft Computing Journal*, Vol. 38, pp. 106-117.

Ferreira, F.A., Ilander, G.O.P.B. and Ferreira, J.J. (2019), "MCDM/A in practice: methodological developments and real-world applications", *Management Decision*, Vol. 52 No. 2, pp. 295-299.

Fonseca, M.B.F., Ferreira, F.A., Fang, W. and Jalali, M.S. (2018), "Classification and selection of tenants in residential real estate: A constructivist approach", *International Journal of Strategic Property Management*, Vol. 22 No. 1, pp. 1-11.

Frank, H.F. (2006), "Some considerations when selecting digital library software", *OCLC Systems and Services*, Vol. 22 No. 2, pp. 107-110.

Gerogiannis, V.C., Rapti, E. and Karageorgos, A. (2015), "A fuzzy linguistic approach for human resource evaluation and selection in software projects", in *International Conference on Industrial Engineering and Operations Management*. Dubai, IEEE.

Gkoumas, G., Lazarinis, F., Gkoumas, G., Lazarinis, F., Butler, P. and Collins, N. (2015), "Evaluation and usage scenarios of open source digital library and collection management tools", *Program: Electronic Library and Information System*, Vol. 49 No. 3, pp. 226-241.

Gonçalves, J.M., Ferreira, F.A., Ferreira, J.J. and Farinha, L.M. (2019), "A multiple criteria group decision-making approach for the assessment of small and medium-sized enterprise competitiveness", *Management Decision*, Vol. 57 No. 2, pp. 480-500.

Gumus, A.T. (2009), "Evaluation of hazardous waste transportation firms by using a two-step fuzzy-AHP and TOPSIS methodology", *Expert Systems with Applications*, Vol. 36 No. 2, pp. 4067-4074.

Han, Y. (2004), "Digital content management: The search for a content management system", *Library Hi Tech*, Vol. 22 No. 4, pp. 355-365.

Hanine, M., Boutkhoum, O., Tikniouine, A. and Agouti, T. (2016), "Application of an integrated multi - criteria decision making AHP - TOPSIS methodology for ETL software selection", *SpringerPlus*, Vol. 5 No. 1, 263.

Hanumappa, A., Dora, M. and Navik, V. (2014), "Open source software solutions in Indian libraries", *Library Hi Tech*, Vol. 32 No. 3, pp. 409-422.

Harris, P.A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N. and Conde, J.G. (2009), "Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support", *Journal of Biomedical Informatics*, Vol. 42 No. 2, pp. 377-381.

Hatefi, S. and Tamošaitienė, J. (2019), "An integrated fuzzy DEMATEL-fuzzy ANP model for evaluating construction projects by considering interrelationships among risk factors", *Journal of Civil Engineering and Management*, Vol. 25 No. 2, pp. 114-131.

Hoadley, C.M., Xu, H., Lee, J.J. and Beth, M. (2010), "Electronic commerce research and applications privacy as information access and illusory control: The case of the Facebook News Feed privacy outcry", *Electronic Commerce Research and Applications*, Vol. 9 No. 1, pp. 50-60.

Hsu, Y.L., Lee, C.H. and Kreng, V.B. (2010), "The application of Fuzzy Delphi Method and Fuzzy AHP in lubricant regenerative technology selection", *Expert Systems with Applications*, Vol. 37 No. 1, pp. 419-425.

Hu, K.-H., Chen, F.-H. and Tzeng, G.-H. (2018b), "CPA firm's cloud auditing provider for performance evaluation and improvement: an empirical case of China", *Technological and Economic Development of Economy,* Vol. 24 No. 6, pp. 2338-2373.

Hu, K.-H., Jianguo, W. and Tzeng, G.-H. (2018a), "Improving China's regional financial center modernization development using a new hybrid MADM model", *Technological and Economic Development of Economy,* Vol. 24 No. 2, pp. 429-466.

Iqbal, M. and Warraich, N.F. (2012). "Usability evaluation of an academic library website: A case of the University of the Punjab", *Pakistan Journal of Library and Information Science*, Vol. 13, pp. 1-11.

Jeng, J. (2005), "What is usability in the context of the digital library and how can it be measured?", *Information Technology and Libraries*, Vol. 24 No. 2, pp. 47-56.

Joo, S. and Lee, J.Y. (2011), "Measuring the usability of academic digital libraries instrument development and validation", *The Electronic Library*, Vol. 29 No. 4, pp. 523-537.

Kaklauskas, A., Rutė, J., Gudauskas, R. and Banaitis, A. (2011), "Integrated model and system for passive houses multiple criteria analysis", *International Journal of Strategic Property Management*, Vol. 15 No. 1, pp. 74-90.

Kaklauskas, A., Zavadskas, E.K., Babenskas, E., Seniut, M., Vlasenko, A. and Plakys, V. (2007), "Intelligent library and tutoring system for Brita in the PuBs project", in Luo, Y. (Ed.), Cooperative Design, Visualization, and Engineering, CDVE 2007. *Lecture Notes in Computer Science*, Vol. 4674, Springer, Berlin, Heidelberg, pp. 157-166.

Kaushik, S. and Somvir, R. (2015), "DEMATEL: A methodology for research in library and information science", *International Journal of Librarianship and Administration*, Vol. 6 No. 2, pp. 179-185.

Kaushik, S., Somvir, R. and Ranjan Kumar, S. (2015), "Free or Open Sources Software (FOSS): A study of Greenstone Digital Library Software," *International Journal of Information Technology and Library Science*, Vol. 4 No. 1, pp. 17-25.

Kobayashi, M. and Takeda, K. (2000), "Information retrieval on the web", *ACM Computing Surveys*, Vol. 32 No. 2, pp. 144-173.

Kong, F.C. and Cao, Y.X. (2010), "Service quality evaluation of library based on Fuzzy Multiple Index and TOPSIS approach", *Information Science*, Vol. 3 No. 21.

Kumar, A. and Dash, M.K. (2016), "Using DEMATEL to construct influential network relation map of consumer decision-making in e-marketplace", *International Journal of Business Information Systems*, Vol. 21 No. 1, pp. 48-72.

Kumar, A. and Dash, M.K. (2017), "Causal modelling and analysis evaluation of online reputation management using fuzzy Delphi and DEMATEL", *International Journal of Strategic Decision Sciences*, Vol. 8 No. 1, pp. 27-45.

Kumar, A., Kaviani, M., Hafezalkotob, A. and Zavadskas, E. (2017), "Evaluating innovation capabilities of real estate firms: A combined fuzzy Delphi and DEMATEL approach", *International Journal of Strategic Property Management*, Vol. 21 No. 4, pp. 401-416.

Kumar, A., Kaviani, M.A., Bottani, E., Dash, M.K. and Zavadskas, E.K. (2018), "Investigating the role of social media in polio prevention in India: A Delphi-DEMATEL approach", *Kybernetes*, Vol. 47 No. 5, pp. 1053-1072.

Lai, C.F., Chiu, P.S., Huang, Y.M., Chen, T.S. and Huang, T. C. (2014), "An evaluation model for digital libraries' user interfaces using fuzzy AHP", *The Electronic Library*, Vol. 32 No. 1, pp. 83-95.

Langville, A.N. and Meyer, C.D. (2005), "A survey of eigenvector methods for web information retrieval", *SIAM Review*, Vol. 47 No. 1, pp. 135-161.

Lin, H.F. (2010), "An application of fuzzy AHP for evaluating course website quality", *Computers & Education*, Vol. 54 No. 4, pp. 877-888.

Lopez, J., Oppliger, R. and Pernul, G. (2004), "Authentication and authorization infrastructures (AAIs): A comparative survey", *Computers and Security*, Vol. 23 No. 7, pp. 578-590.

Magnussen, A. (2003), "Creating digital libraries: a model for digital library development", *Paper presented in the 10th Asia Pacific Special Health and Law Librarians Conference*, 24-27 August, Adelaide.

Mangla, S.K., Luthra, S., Jakhar, S.K., Tyagi, M. and Narkhede, B.E. (2018), "Benchmarking the logistics management implementation using Delphi and fuzzy DEMATEL", *Benchmarking: An International Journal*, Vol. 25 No. 6, pp. 1795-1828.

Mavi, R.K., Gheibdoust, H., Khanfar, A.A. and Mavi, N.K. (2019), "Ranking factors influencing strategic management of university business incubators with ANP", *Management Decision*, Vol. 57 No. 12, pp. 3492-3510.

Nakhoda, M., Alidousti, S. and Fadaie, G.R. (2011), "Selecting an appropriate change management model for Iranian Academic Libraries using MADM Methods", *Libri*, Vol. 61 No. 3, 190-204.

Nurmikko-Fuller, T., Dix, A., Weigl, D.M. and Page, K.R. (2016), "In collaboration with in concert: reflecting a digital library as linked data for performance ephemera", in *3rd International workshop on Digital Libraries for Musicology*, USA, ACM, pp. 17-24.

Nursal, A.T., Omar, M.F. and MohdNawi, M.N. (2015), "Decision support evaluation for building information modeling software selection", *Jurnal Teknologi (Sciences & Engineering)*, Vol. 75 No. 9, pp. 117-122.

Okhovati, M., Karami, F. and Khajouei, R. (2016), "Exploring the usability of the central library websites of medical sciences universities", *Journal of Librarianship and Information Science*, Vol. 49 No. 3, pp. 246-255.

Pandey, S. and Panda, K.C. (2014), "Semantic solutions for the digital libraries based on semantic web technologies", *Annals of Library and Information Studies*, Vol. 61, pp. 286-293.

Park, T. and Sinn, D. (2016), "Evaluation of Open-source Software for Participatory Digital Archives: Understanding System Requirements for No Gun Ri Digital Archives", *Journal of Korean Society of Archives and Records Management*, Vol. 16 No. 1, pp. 121-150.

Paz, F. & Pow-sang, J.A. (2016), "A systematic mapping review of usability evaluation methods for software development process", *International Journal of Software Engineering and Its Applications*, Vol. 10 No. 1, pp. 165-178.

Pires, A.S., Ferreira, F.A., Jalali, M.S. and Chang, H.C. (2018), "Barriers to real estate investments for residential rental purposes: Mapping out the problem", *International Journal of Strategic Property Management*, Vol. 22 No. 3, pp. 168-178.

Rafiq, M., Ameen, K. and Jabeen, M. (2018), "Barriers to digitization in university libraries of Pakistan: A developing country's perspective", *Electronic Library*, Vol. 36 No. 3, pp. 457-470.

Rao, P.V. and Kumar, B. (2016), "Open Source Software (Digital Libraries): With Special Reference to Koha and Dspace", *International Journal of Innovative Research and Development*, Vol. 5 No. 2, pp. 214-218.

Ravikumar, M.N. and Ramanan, T. (2015), "Comparison of Greenstone Digital Library and DSpace: Experiences from Digital Library Initiatives at Eastern University, Sri Lanka", *Journal of the University Librarians Association of Sri Lanka*, Vol. 18 No. 2, pp. 76-90.

Robbins, S., Engel, D., & Bierman, J. (2006), "Using the library intranet to manage web content", *Library H*, Vol. 24 No. 2, pp. 261-272.

Rosa, C.A., Craveiro, O. and Domingues, P. (2017), "Open Source Software for digital preservation repositories: A survey", *International Journal of Computer Science & Engineering Survey (IJCSES)*, Vol. 8 No. 3, pp. 21-39.

Schatz, B.R. (1997), "Information Retrieval Bringing Search in Digital to the Libraries: Net", *Bioinformatic*, Vol. 275 No. 5298, pp. 327-334.

Seadle, M. (2006), "Content management systems", *Library Hi Tech*, Vol. 24 No. 1, pp. 5-7.

Shoeb, Z.H. (2010), "Authentication and authorization: Security issues for institutional digital repositories", *Library Philosophy and Practice*, 2010, 1–6.

Song, W., Zhu, Y. and Zhao, Q. (2020), "Analyzing barriers for adopting sustainable online consumption: A rough hierarchical DEMATEL method", *Computers & Industrial Engineering*, 106279.

Sullivan, R. (2002), "Indigenous cultural and intellectual property rights", *D-Lib Magazine*, Vol. 8 No. 5.

Tien-Yum, H., Hao-Ren Ke and Yang, W.-P. (2006), "Unified knowledge-based content management for digital archives in museums", *The Electronic Library*, Vol. 24 No. 1, pp. 38-50.

Wales, T. (2005), "Library subject guides: A content management case study at the Open University, UK ", *Program: Electronic Library and Information System*, Vol. 39 No. 2, pp. 112-121.

Wu, C.M., Hsieh, C.L. and Chang, K.L. (2013), "A model for assessing the service quality of university library websites", *Mathematical Problems in Engineering*, 2013. https://www.hindawi.com/journals/mpe/2013/363486/

Xi, Q., Zhao, H., Hu, Y., Tong, Y. and Bao, P. (2018), "Case studies and comparison between two models for assessing library service quality", *The Electronic Library,* Vol. 36 No. 6, pp. 1099-1113.

Yazdani, M., Wen, Z., Liao, H., Banaitis, A. and Turskis, Z. (2019), "A grey combined compromise solution (CoCoSo-G) method for supplier selection in construction management", *Journal of Civil Engineering and Management*, Vol. 25 No. 8, pp. 858-874.

Zavadskas, E.K., Kaklauskas, A. and Banaitis, A. (2011), "The use of the intelligent library and tutoring system at all stages of a building life cycle", *Inzinerine ekonomika-Engineering Economics,* Vol. 22 No. 1, pp. 14-23.

Zavadskas, E.K., Kaklauskas, A. and Tamošaitienė, J. (2013), "Intelligent library model and system", in *Proceedings of the 14th German-Lithuanian-Polish Colloquium on Innovative solutions in construction technology and management, Vilnius, Lithuania, 15 May 2013*, Technika, Vilnius, pp. 45-52.

Zavadskas, E.K., Kaklauskas, A., Vlasenko, A. and Gulbinas, A. (2007), "Intelligent library and tutoring system for Brita in PuBs project", in *Proceedings of the 9th international conference on Modern building materials, structures and techniques, Vilnius, Lithuania 16-18 May, 2007*, Technika, Vilnius, pp. 433-437.

Appendix

Table AI. DELPHI questionnaire

Please respond to the questionnaire about the importance of factors related to the adoption of green stone software in digital library on the basis of the following scale: 5 = extremely important, 4 = important, 3 = normal, 2 = unimportant, 1 = extremely unimportant.

Factors	Response
Content acquisition	
Content management	
User friendly interface and Usability	
Classification	
Information search and retrieval	
Access control, privacy and management	
Authentication and authorization	
Interoperability	
Ease of deployment of each softwares	
Metadata submission and support	
Flexibility and Freedom	
Copyright issue/policies	

Table AII. DEMATEL questionnaire

On the basis of the scale (Very high influence = 4 to No influence = 0) to measure the relation among the factors this questionnaire is designed.

Please tick (√) in appropriate box

With respect to : The overall Goal		Compare the influence of one main factor over another							
Main Attributes Effect Main Attributes		Content Acquisition (F1)	Content Management (F2)	User friendly interface and Usability (F3)	Classification (F4)	Information Search and Retrieval (F5)	Access Control, Privacy and Management (F6)	Authentication and Authorization (F7)	Metadata Submission and Support (F8)
F1	4	0							
	3								
	2								
	1								
	0								
F2	4		0						
	3								
	2								

	1								
	0								
F3	4			0					
	3								
	2								
	1								
	0								
F4	4				0				
	3								
	2								
	1								
	0								
F5	4					0			
	3								
	2								
	1								
	0								
F6	4						0		
	3								
	2								
	1								
	0								

Table I.

Final identified factors to implement GSDL software in the library with support references

Factors	Support references
Access control, privacy and management	Frank (2006), Dixon (2008), Lopez *et al*. (2004), Colombo and Ferrari (2015), Hoadley *et al.* (2010)
Authentication and authorization	Bellido *et al*. (2010), Frank (2006), Dixon (2008), Lopez *et al*. (2004)
Classification	Lopez *et al*. (2004), Schatz (1997), Kaklauskas *et al.* (2007), Zavadskas *et al*., (2007, 2011, 2013)
Content acquisition	Tien-Yu (2006), Wales (2005), Robbins *et al*. (2006)
Content management	Magnussen (2003), Sullivan (2002), Han (2004), Boiko (2002), Seadle (2006)
Information search and retrieval	Frank (2006), Wales, T. (2005), Ding, Y. *et al*. (2000), Lengville and Meyer (2005), Kobayashi (2000), Kaklauskas *et al.* (2007), Zavadskas *et al*., (2007, 2011, 2013)
Metadata submission and support	Bowen (2008), Harris *et al*. (2009), Beyene, W.M. (2017), Cheetham *et al*. (2014)
User-friendly interface and Usability	Frank (2006), Bellido *et al*. (2010), Schatz (2014), Ackermann (2003), Chowdhury *et al*. (2006), Iqbal and Warraich (2012), Jeng (2005), Okhovati *et al*. (2016), Paz *et al*. (2016)

Table II.

Applications of MCDM methods in library science

Author(s)	Applied method	Application in library science
Hanine *et al.* (2016)	AHP and TOPSIS	For ETL software selection
Nursal *et al.* (2015)	TOPSIS	Modeling software selection
Efe (2015)	Fuzzy AHP and Fuzzy	ERP system selection
Wu *et al.* (2013)	Fuzzy Delphi and ANP	Assessing the service quality of university library websites
Cabrerizo *et al.* (2010)	Fuzzy linguistic modeling	Evaluate the quality of digital libraries
Chen (2016)	DEMATEL	Service quality: a case study of an academic library
Kong and Cao (2010)	Fuzzy Multiple Index and TOPSIS	Service quality evaluation of library
Nakhoda *et al.* (2011)	TOPSIS and SAW	Selecting an appropriate change management model
Xi *et al.* (2018)	AHP	Assessing library service quality
Lai *et al.* (2014)	Fuzzy AHP	An evaluation model for digital libraries' user interfaces
Cunkun *et al.* (2014)	AHP	Service evaluation
Lin (2010)	Fuzzy AHP	Evaluating course website quality

Table III.

Finalization of factors

Factors	Importance	Result
Access control, privacy and management	4.15	Accepted
Authentication and authorization	4.05	Accepted
Classification	3.85	Accepted
Content acquisition	4.10	Accepted
Content management	4.20	Accepted
Copyright issue/policies	3.75	Rejected
Ease of deployment of each softwares	3.65	Rejected
Information search and retrieval	4.05	Accepted
Interoperability	2.99	Rejected
Metadata submission and support	3.91	Accepted
Flexibility and freedom	3.65	Rejected
User friendly interface and usability	3.85	Accepted

Table IV.

Average matrix

	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.00	2.75	2.67	2.58	1.92	2.33	2.08	2.00
F2	2.67	0.00	3.08	2.92	2.92	2.33	2.92	2.00
F3	3.08	3.08	0.00	3.67	2.92	3.42	3.33	2.58
F4	2.00	2.50	2.75	0.00	3.25	2.83	3.33	2.33
F5	3.25	2.92	2.83	3.25	0.00	3.42	3.08	2.08
F6	2.50	1.75	2.08	3.08	3.42	0.00	2.33	1.75
F7	3.42	2.67	3.83	2.08	3.17	2.58	0.00	2.67
F8	2.08	2.67	1.42	2.50	2.17	1.33	2.92	0.00

Table V.
Ranks and impacts

	r_i	c_j	r_i+c_j	Rank	r_i-c_j	Impact
F1	5.021	5.765	10.785	7	-0.744	Effect
F2	5.750	5.559	11.309	5	0.191	Cause
F3	6.569	5.710	12.279	1	0.859	Cause
F4	5.791	6.031	11.822	4	-0.239	Effect
F5	6.241	5.965	12.205	2	0.276	Cause
F6	5.204	5.593	10.797	6	-0.390	Effect
F7	6.009	6.008	12.108	3	0.141	Cause
F8	4.667	4.760	09.427	8	-0.094	Effect

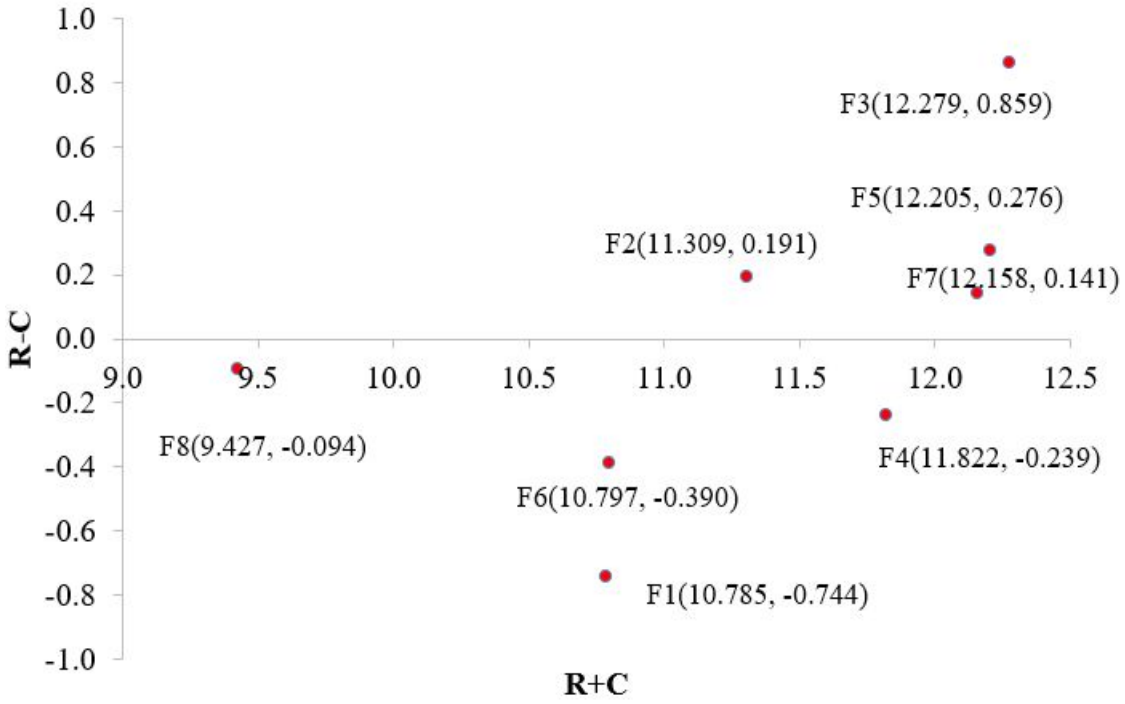

Figure 1.

Cause-Effect evaluation model

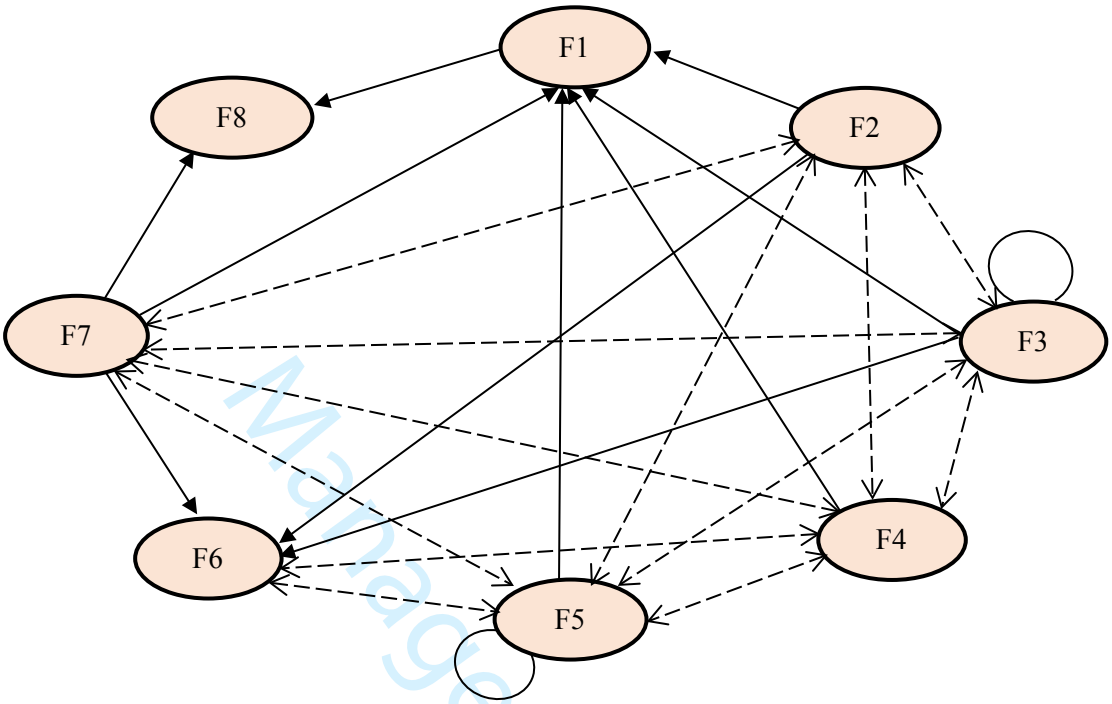

Figure 2.

Inter-relationship digraph between factors