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Digital Library Evaluation by SWARA-WASPAS Method

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***Abstract*—**Since the discovery of the manuscript, mechanical methods for storing, transferring and using the information have evolved into digital methods over the time. In this process, libraries that are the center of the information have also become digitized and become accessible from anywhere and at any time in the world by taking on a structure that has no physical boundaries. In this context, some criteria for information obtained from digital libraries have become more important for users. This paper evaluates the user criteria from different perspectives that make a digital library more useful. The Step-Wise Weight Assessment Ratio Analysis-Weighted Aggregated Sum Product Assessment (SWARA-WASPAS) method is used with flexibility and easy calculation steps for the evaluation of digital library criteria. Three different digital libraries are evaluated by information technology experts according to five conflicting main criteria, 'interface design', 'effects on users', 'services', 'user engagement' and 'context'. Finally, alternatives are ranked in descending order.

***Keywords*—**Digital library, multi criteria decision making, SWARA-WASPAS method.

I. Introduction

WITH the usage of the manuscript by Sumerians in 3500 BC, information could be stored and transmitted. Approximately 5000 years later, in the 1450s AC, it was possible to spread information rapidly to the masses through the use of the printing press. After World War II, there was a great increase in the number of books and magazines. With the use of the computer, the processing of information has been facilitated; change and transformation have increased in this area [1]. The process of storing information, which started with handwriting, continued with mechanical methods, like in the first calculator. With the use of punched card systems, it has been carried out in an electro-mechanical structure. Today, it has been moved to a digital environment with the use of computers. With digitalization, the ability and capacity of classification, calculation, summarization, reporting, storage, access and replication of information has increased [2].

Librarianship has also evolved in the process of digitization. The design and use of the systems that refresh the information management and facilitating access to the information resources could have been possible with digital libraries (DLs). Digital Library Federation offered the following definition: "Digital libraries are organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities" [3].

The evolution of DLs has evolved over the years from simple interfaces to complex networks that allow users around the world to collaborate and share the information. Thanks to the contemporary DL, people have access, debate, evaluate, and improve different content of information [4].

DLs usage has become more widespread in the discipline of information science and library today. They supply consistency and economy in the use of digital services to library users in much different geography. The digital services consist desktops, electronic publishing (e-publishing), web-portal, online database, electronic books (e-books), electronic journal (e-journal), etc. When DLs and traditional libraries compared to each other, the most important difference issue is the need for physical space. DLs need very little space; sometimes they do not need any physical space. DLs are also capable of storing much more information than the traditional ones. The most important advantage of DLs is undisputed increased access unlike the traditional libraries; no geographical constraint could prevent from accessing them. However, the DLs users could able to access to DLs at any time and at any place, thus saving a significant amount of time for users [5].

For designing a digital information system, such as DLs, the first aim to be met is to facilitate the intuitive tools needed for information users. In order to achieve this goal, the organization, labeling, navigation and search systems must also be designed appropriately for controlled words that represent this digital environment [6].

When designing a system, the needs and evaluations of the users are guiding. Therefore, decisions should be made by evaluating the different perspectives and different criteria to make the decision without being overlooked. For this reason, using a multi criteria decision making method is an effective way for evaluation of DLs.

Providing flexibility and easy computational steps are very important in multi criteria decision making (MCDM). Therefore, Step-Wise Weight Assessment Ratio Analysis-Weighted Aggregated Sum Product Assessment (SWARA-WASPAS) method is used to overcoming this challenge. The details of the method are defined in Section III.

DLs and SWARA-WASPAS method related papers are

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presented in Section II, and the steps of SWARA-WASPAS method are presented in Section III. In Section IV, an application of evaluating three DLs is given. At the last section, the conclusion is presented to summarize the study and recommendations for the future are given.

II. Literature Review

Sun and Yuan [7] presented an overview of DL studies consists of DL features, advantages, disadvantages and functions. Ahmad and Abawajy [8] proposed a model from the perspective of the digital service providers for evaluating the performance of DL services. Topçu et al. [9] explained data standardization in DLs due to regulations, language and cultural characteristics of the country. Barbuti et al. [4] presented an integrated management system for DLs. They defined a structure that goals to bring together the practice, expertise and software developed by university and companies analysts. Perez-Montoro and Nualart [6] proposed an articulation of navigation and search systems for DLs. Xu and Du [10] pointed out that instead of information quality, system and service quality significantly affected the ease of usage perception for DLs. Li and Liu [11] explored the relationships between user interaction and DLs evaluation. Li et al. [12] focused on the importance of user services and types of big data resources which could be used by DLs. They also examined the problems and capacity of DLs in the age of big data relative to data, technology, services, and users.

Xie et al. [13] presented a very remarkable study in terms of the evaluation criteria for DLs. In this study, a multifaceted evaluation was presented by using 10 main criteria with 94 sub-criteria. These criteria are "collections" (digitization standards, authority, cost, item quality, format compatibility, audience, scope/coverage, contextual information, completeness, diversity and size), "information organization" (appropriateness, accessibility to metadata, metadata accuracy, metadata standards, consistency, comprehensiveness, depth of metadata, metadata interoperability and controlled vocabulary), "interface design" (search function, browsing function, navigation, intuitive operation, search results presentation, consistency, reliability, help function, visual appeal, user control and personalized page), "system and technology" (retrieval effectiveness, reliability, server performance, response time, fit-to-task, connectivity, page loading speed, integrated search, error rate/error correction, flexibility and linkage with other DLs), "effects on users" (research productivity, learning effects, knowledge change, instructional efficiency, perception of DLs, information literacy/skill change), "services" (service quality, usefulness, user satisfaction, types of services for users w/ disabilities, reliability, responsiveness, timeliness, types of services, availability of DL staff, confidence, follow-up services, frequently asked questions/questions and answers, user education, types of unique services and customized services), "preservation" (completeness, ability to migrate, preservation policy, preservation infrastructure, institutional support, types of archiving methods and cost per record), "administration" (budget, planning, staffing, staff training, marketing, regular assessment, management policy, fundraising/sponsor and incentive), "user engagement" (resource use, user feedback, site visit, integration with external applications, help feature use, user participation channels, user knowledge contribution and e-commerce support) and "context" (copyright, information ethics compliance, organizational mission, targeted user community, content sharing, collaboration and social impact).

SWARA and WASPAS were presented in 2010 [14] and 2012 [15]. They were applied to solve real problems in life. SWARA was used for architect selection [16], Zolfani et al. [17] used SWARA to make business decisions and to design products [18]. Aghdaie et al. [19] used SWARA for selection of machine tool. For selection of deep-water port, WASPAS was used by Bagoˇcius et al. [20]. Zavadskas et al. [21] used WASPAS for assessment of facade alternatives. Dˇejus and Antuchevičienė [22] used WASPAS for health and safety issues in construction area. Bitarafan et al. [23] used WASPAS to evaluate of bridge sensors for structural health monitoring.

In this paper, DLs are evaluated by SWARA-WASPAS for the first time in the literature.

III. SWARA-WASPAS Method

The SWARA method is one of the new MCDM methods presented by Keršuliene et al. [14]. The WASPAS method is a unique combination of Weighted Sum Model (WSM) And Weighted Product Model (WPM), developed by Zavadskas et al. [15]. In this section, the SWARA method and the WASPAS method are explained step by step.

A. SWARA Method

The SWARA method was developed by *Keršuliene et al.* [14] and the steps of the method can be clarified as follows;

- Step 1: The criteria are organized in descending order respect to their expected significances.
- Step 2: The expert expresses the relative importance of criterion j in relation to previous (j-1) criterion and this process starts from the second criterion. The determined relative importance is represented by S_j.
- Step 3. The coefficient k_j is calculated as follows:

$$k_j = \begin{cases} 1 & j=1 \\ s_j+1 & j>1 \end{cases} \quad (1)$$

- Step 4. The recalculated weight q_j is calculated as follows:

$$q_j = \begin{cases} 1 & j=1 \\ \dfrac{k_{j-1}}{k_j} & j>1 \end{cases} \quad (2)$$

- Step 5. The criteria's relative weights are calculated as:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (3)$$

where W_j denotes the relative weight of criterion j.

B. WASPAS Method

The steps of the WASPAS method, developed by 15], are given as the following:

- Step 1: Carry out linear normalization of performance values as in the following

  j=1,2,…,n (set of alternatives)

  i=1,2,…,n (set of criteria)

$$\bar{x}_{ij}=\begin{cases}\frac{x_{ij}}{\max\limits_i x_{ij}} \ if\ i\in C_b\\ \frac{\min\limits_i x_{ij}}{x_{ij}} if\ i\in C_n\end{cases} \quad (4)$$

where C_b and C_n are the sets of benefit and cost criteria.

- Step 2: Compute the measures of WSM $\left(Q_j^1\right)$ and WPM $\left(Q_j^2\right)$ for each alternative using:

$$Q_j^1=\sum_{i=1}^m w_i\ \bar{x}_{ij} \quad Q_j^2=\sum_{i=1}^m\left(\bar{x}_{ij}\right)^{w_i} \quad (5)$$

- Step 3: Compute the aggregated measure of the WASPAS method for each alternative using:

$$Q_j=\lambda Q_j^1+(1-\lambda)Q_j^2,\ \ \lambda=0,\dots,1 \quad (6)$$

where λ is the parameter of the WASPAS method. When λ=0, WASPAS becomes WPM; and When λ=1, WASPAS becomes WSM. In our research' we use λ=0.5 for evaluation of alternatives.

- Step 4: Rank the alternatives according to decreasing values of Q_i

$$Q_j^1=\sum_{i=1}^m w_i\ \bar{x}_{ij} \quad (7)$$

IV. Application

DLs can be evaluated from a system-oriented or user-oriented perspective. In our study, we discussed the criteria set by Xie et al. [13] which are important only for users. These are "interface design (C_1)", "effects on users (C_2)", "services (C_3)", "user engagement (C_4)" and "context (C_5)".

In the application section, three different DL alternatives were evaluated according to five different criteria. The relative weights of criteria were determined by the SWARA method, and the relative weights of alternatives were determined by the WASPAS method. Three information technology experts were used to evaluate the criteria. The decision matrix was created by agreed decision by three experts. Three experts discussed about which criterion is the most important, and the first criterion "interface design" was selected as the most important criterion. Then, the steps of SWARA were implemented, and Table I shows the calculation results of SWARA steps.

After getting criteria weights by the SWARA method, relative weights of alternatives were computed using the WASPAS method. Experts evaluate the alternatives by using 1-7 Likert scale and all the criteria are benefit criteria. Table II shows the evaluation of alternatives according to the criteria.

TABLE I
CALCULATION RESULTS FOR WEIGHTS OF CRITERIA

Criterion	s_j	k_j	q_j	w_j
C_1		1,00	1,0	0,32
C_2	0,20	1,20	0,84	0,27
C_3	0,40	1,40	0,60	0,19
C_4	0,50	1,50	0,40	0,12
C_5	0,60	1,60	0,25	0,08
			$\sum q_j = 3{,}09$	$\sum w_j = 1$

TABLE II
DECISION MATRIX OF THE DLS EVALUATION

	C_1	C_2	C_3	C_4	C_5
Weights	0.32	0.27	0.19	0.12	0.08
A_1	7	4	7	4	3
A_2	6	6	5	5	3
A_3	4	7	3	7	4

First, we normalize the decision matrix by (4); the normalized matrix can be seen in Table III.

TABLE III
NORMALIZED DECISION MATRIX FOR DLS EVALUATION

	C_1	C_2	C_3	C_4	C_5
A_1	1.00	0.57	1.00	0.57	0.75
A_2	0.86	0.86	0.71	0.71	0.75
A_3	0.57	1.00	0.43	1.00	1.00

Then, we compute the measures of WSM and WPM for each alternative. Table IV presents WSM, WPM and WASPAS results obtained by (5)-(7).

TABLE IV
WSM, WPM AND WASPAS RESULTS OF ALTERNATIVES

	Q_j^1	Q_j^2	Q_j	Ranking
A_1	0.703	0.776	0.740	2
A_2	0.703	0.798	0.751	1
A_3	0.700	0.754	0.727	3

According to Table IV, ranking of alternatives is $A_2>A_1>A_3$.

V. Conclusion

Due to developing technology, fast access to information provides many advantages, thus human beings are seeking the fastest way to reach information. DLs have more content and capacity than just literature, easy access to and use of information.

Due to the increasing interest in DLs, their numbers are increasing day by day. It is important to prepare the content and technology background of DLs by experts.

In this paper, three different DLs are evaluated according to five conflicting criteria. Criteria are selected from the literature survey, and their relative weights are determined by the SWARA method. Then, three different alternatives are evaluated by using the WASPAS method. Finally, alternatives

are ranked in descending order.

For further research, the obtained results of our paper can be compared by the results of other multi-criteria methods like EDAS, ELECTRE, or VIKOR.

REFERENCES

[1] M. Kurulgan, "The effects of information technology on library and documentation centers: A review of social, structural, managerial and functional aspects", *Türk Kütüphaneciliği (Turkish Librarianship),* vol. 27, no. 3, pp. 472-495, 2013.

[2] T. K. Bensghir, "Bilgi sistemleri ve bilgi yönetimi (Knowledge systems and knowledge management)", *TODAIE e-Devlet Merkezi Bilgi Yönetimi Semineri*, Ankara, 23 November 2011.

[3] S. Virkus, "Definition of digital libraries", Available at:https://www.tlu.ee/~sirvir/Information%20and%20Knowledge%20Management/Integration%20of%20digital%20libraries%20in%20e-learning/definition_of_digital_libraries.html, 2019.

[4] N. Barbuti, S. Ferilli, D. Redavid and T. Caldarola, "An integrated management system for multimedia digital library", *Procedia Computer Science,* vol. 38, pp. 128 – 132, 2014.

[5] K. Kaur and S. Diljit, "Modelling web-based library service quality", *Library Information Science Research*, vol. 34, no. 3, pp. 184-196, 2012.

[6] M. Pérez-Montoro and J. Nualart, "Visual articulation of navigation and search systems for digital libraries", *International Journal of Information Management*, vol. 35, pp. 572–579, 2015.

[7] J. Sun, and B. Z. Yuan, "Development and characteristic of digital library as a library branch", *IERI Procedia,* vol. 2, pp. 12 – 17, 2012.

[8] M. Ahmad and J. H. Abawajy, "Digital library service quality assessment model", *Procedia - Social and Behavioral Sciences,* vol. 129, pp. 571 – 580, 2014.

[9] Ö. Ş. Topçu, T. Çakmak and G. Doğan, "Data standardization in digital libraries: An ETD case in Turkey", *Procedia - Social and Behavioral Sciences,* vol. 147, pp. 223 – 228, 2014.

[10] F. Xu and J. T. Du, "Factors influencing users' satisfaction and loyalty to digital libraries in Chinese universities", *Computers in Human Behavior,* vol. 83, pp. 64-72, 2018.

[11] Y. Li and C. Liu, "Information resource, interface, and tasks as user interaction components for digital library evaluation", *Information Processing and Management,* vol. 56, pp. 704–720, 2019.

[12] S. Li, F. Jiao, Y. Zhang and X. Xu, "Problems and changes in digital libraries in the age of big data from the perspective of user services", *The Journal of Academic Librarianship,* vol. 45, pp. 22–30, 2019.

[13] I. Xie, S. Joo and K. K. Matusiakc, "Multifaceted evaluation criteria of digital libraries in academic settings: Similarities and differences from different stakeholders", *The Journal of Academic Librarianship,* vol. 44, pp. 854–863, 2018.

[14] V. Keršuliene, E. K. Zavadskas and Z. Turskis, Z. "Selection of rational dispute resolution method by applying new stepwise weight assessment ratio analysis (SWARA)", *Journal of Business Economics and Management,* vol. 11, no. 2, pp. 243–258, 2010.

[15] E. K. Zavadskas, Z. Turskis, J. Antucheviciene and A. Zakarevicius, "Optimization of weighted aggregated sum product assessment", *Electronics and Electrical Engineering*, vol. 6, pp. 3–6, 2012.

[16] V. Ker˘sulien˙e, and Z. Turskis, "Integrated fuzzy multiple criteria decision making model for architect selection", *Technol. Econ. Dev. Econ.*, vol. 17, pp. 645–666, 2011.

[17] S. H. Zolfani, M. H. Aghdaie, A. Derakhti, E. K. Zavadskas and M. H. M. Varzandeh, "Decision making on business issues with foresight perspective; An application of new hybrid MCDM model in shopping mall locating", *Expert Syst. Appl.,* vol. 40, pp. 7111–7121, 2013.

[18] S. H. Zolfani, E. K. Zavadskas and Z. Turskis, "Design of products with both international and local perspectives based on yin-yang balance the oryand SWARA method", *Econ. Res. Ekonomska Istra˙zivanja,* vol. 26, pp. 153–166, 2013.

[19] M. H. Aghdaie, S. H. Zolfani and E. K. Zavadskas, "Decision making in machine tool selection: an integrated approach with SWARA and COPRAS-G methods", *Inzinerine Ekonomika-Engineering Economy*, vol 24, pp. 5–17, 2013.

[20] V. Bago˘cius, K. E. Zavadskas and Z. Turskis, "Multi-criteria selection of a deep-water port in Klaipeda", *Procedia Eng.,* vol. 57, pp. 144–148, 2013.

[21] E. K. Zavadskas, J. Antucheviciene, J. ˘Saparauskas and Z. Turskis, "Multi-criteria assessment of facades' alternatives: Peculiarities of ranking methodology", *Procedia Eng.,* vol. 57, pp. 107–112, 2013.

[22] T. D˙ejus and J. Antuchevi˘cien˙e, "Assessment of health and safety solutions at aconstruction site", *Journal of Civil Engineering Management,* vol. 19, pp. 728–737, 2013.

[23] M. Bitarafan, S. H. Zolfani, S. L. Arefi, E. K. Zavadskas, and A. Mahmoudzadeh, "Evaluation of real-time intelligent sensors for structural health monitoring of bridges based on SWARA-WASPAS; A case in Iran", *Baltic J.Road Bridge Eng.,* vol. 9, pp. 333-340, 2014.

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