Project Management Methodology Selection Using SWOT-Fuzzy AHP

Nurgul DEMIRTAS, Umut Rıfat TUZKAYA, and Sukran SEKER

***Abstract*—In this study, outcomes of implementing the agile methodologies to software application development are discussed. An integrated multi-criteria decision making technique is used to obtain reliable results. Firstly, various criteria related with project management methodology are defined by using SWOT. Then selection criteria are specified and weighted by fuzzy AHP. These weights are used in fuzzy AHP technique to determine the precedencies of the alternative project management methodology.**

***Index Terms*— Decision Making, Fuzzy AHP, Project Management Methodology, SWOT,**

I. Introduction

Decision-making process starts from the birth and continues during the life of human. The event of election or a decision making process come into existence if there is a certain period in the solution of specific problems related features that can be used separately for the options [1]. Multi-criteria decision making methods are the methods that allow evaluating of many strategic and operational factors that can be measured and cannot be measured and at the same time they are the analytical methods that include many people into the decision-making process. To use these methods in the decision making process helps to the managers to evaluate alternatives and provides more efficient usage of resources [2].

Software applications have become critical importance and indispensable component of the business with the developing technology. Especially in the banking sector, product development processes begin with software application development. For this reason, successful product development processes are based on fast and high-quality software development processes. A software development process is there to help us build and deliver high quality software to satisfy customer/market demands.

Waterfall models have been used for many years in the software development projects. However, alternative have been emerged. Agile software development is a new paradigm in information systems development that provides a way to organize complex multi-participant software development while accommodating constant project change. Agile software development is a group of software development methods based on iterative and incremental development.[3]

In this study, outcomes of implementing the agile and waterfall methodologies to software application development are discussed and compared in detail using Fuzzy AHP-SWOT. There are many important criteria that affect the methodology decisions like etc.

N.D is with the Department of Industrial Engineering, Yildiz Technical University, Besiktas Istanbul, 34349, Turkey
(e-mail:nurguldemirtas@gmail.com)

U. R. T is with the Department of Industrial Engineering, Yildiz Technical University, Besiktas Istanbul, 34349, Turkey(e-mail:tuzkaya@gmail.com)

S. S. is with the Department of Industrial Engineering, Yildiz Technical University, Besiktas Istanbul, 34349, Turkey(e-mail:seker.sukran@gmail.com)

II. METHODOLOGY

A. SWOT

According to [4,5,6] SWOT analysis, which originates from the business management literature and was adopted in the 1980s by public administration across such areas as regional development and municipal planning [7]. SWOT analysis is a primer tool to the strategic planning process. There are four categories that are obtained in SWOT analysis: strengths, weaknesses, opportunities, and threats. Force field analysis supplements SWOT analysis by identifying the forces driving the strengths, weaknesses, opportunities, and threats [8].

[9,10] present that SWOT analysis is a precursor for analyzing environments to obtain both a systematic approach and support for a decision situation [11].

[12], [13], [14] used SWOT-AHP technique in areas such as environment, [15] in tourism and [16] in project management. [17] presents a process of integrating competitive strength, the environment, and the firm's strategy. Speed of designing, developing and producing new and less costly products through IT investment has proved to help organizations gain competitive advantage. According to [18] they also added that a market oriented IT company should focus on services that will enhance the relationship with customers and suppliers in order to achieve firm's advantage [19].

B. Fuzzy AHP

Buckley's Fuzzy AHP method is used to fuzzify the hierarchical analysis by allowing fuzzy numbers for the pairwise comparisons and find the fuzzy weights [20].

Step 1 : Construct pairwise comparison matrices among all the elements/criteria in the dimensions of the hierarchy system. Assign linguistic terms to the pairwise comparisons by asking which is the more important of each two elements/criteria.

ISBN: 978-988-19253-5-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Step 2 : To use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Buckley[21] as follows:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{12} \otimes \ldots \otimes \tilde{a}_{in})^{1/n}, \quad \tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \ldots \oplus \tilde{r}_n)^{-1},$$

where $\tilde{a}_{in}$ is fuzzy comparison value of criterion i to criterion n, thus, $\tilde{r}_i$ is geometric mean of fuzzy comparison value of criterion i to each criterion, $\tilde{w}_i$ is the fuzzy weight of the *i*th criterion, can be indicated by a TFN, $\tilde{w}_i = (Lw_i, Mw_i, Uw_i)$. Here Lw_i, Mw_i and Uw_i stand for the lower, middle and upper values of the fuzzy weight of the *i*th criterion.

Step 3 : Take $\tilde{E}_{ij}^k$ to indicate the fuzzy performance value of evaluator k towards alternative i under criterion j, and all of the evaluation criteria will be indicated by $\tilde{E}_{ij}^k = (LE_{ij}^k, ME_{ij}^k, UE_{ij}^k)$.

$$\tilde{E}_{ij} = (1/m) \otimes (\tilde{E}_{ij}^1 \oplus \tilde{E}_{ij}^2 \oplus \ldots \oplus \tilde{E}_{ij}^m) \quad (2)$$

The end-point values LE_{ij}, ME_{ij} and UE_{ij} can be solved by the method put forward by Buckley, that is,

$$LE_{ij} = (\sum_{k=1}^{m} LE_{ij}^k)/m; \quad ME_{ij} = (\sum_{k=1}^{m} ME_{ij}^k)/m; \quad UE_{ij} = (\sum_{k=1}^{m} UE_{ij}^k)/m. \quad (3)$$

Step 4 : The criteria weight vector $\tilde{w} = (\tilde{w}_1, \ldots, \tilde{w}_j, \ldots, \tilde{w}_n)^t$, The fuzzy performance matrix of each of the alternatives $\tilde{E} = (\tilde{E}_{ij})$. The final fuzzy synthetic decision matrix $\tilde{R} = \tilde{E} \circ \tilde{w}$.

$\tilde{R}_i = (LR_i, MR_i, UR_i)$, where LR_i , MR_i and UR_i are the lower, middle and upper synthetic performance values of the alternative i, that is:

$$LR_i = \sum_{j=1}^{n} LE_{ij} \times Lw_j; \quad MR_i = \sum_{j=1}^{n} ME_{ij} \times Mw_j; \quad UR_i = \sum_{j=1}^{n} UE_{ij} \times Uw_j. \quad (4)$$

Step 5 : The procedure of defuzzification is to locate the Best Non-fuzzy Performance value (BNP). To utilize the COA(Center of area) method to find out the BNP is a simple and practical method, and there is no need to bring in the preferences of any evaluators, so it is used in this study. The BNP value of the fuzzy number $\tilde{R}_i$ can be found by the following equation:

$$BNP_i = [(UR_i - LR_i) + (MR_i - LR_i)]/3 + LR_i \quad \forall i. \quad (5)$$

III. CASE STUDY

In this study we propose a methodology to select the most appropriate project management methodology for an International Bank IT department projects using a combination of SWOT matrix and Fuzzy AHP.

Our proposal is to structure a hierarchy for the project management methodology based on a SWOT study, and to use a quantitative technique to estimate a global value for each one of the project management methodologies.

The hierarchy for our problem has been structured in four levels, as we describe next. The first level, as usual, is the goal to be achieved by the decision; the next level is constituted by the four groups of attributes as defined by the SWOT technique: Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T); the third level is about the pairwise of attributes finally, alternatives evaluated.

We evaluated the Waterfall and Agile Methodology that are used to manage IT software applications.

The number of main-criteria that we use to solve the problem is four and the number of sub-criteria is thirteen. The criteria are explained below:

Strengths: *Experience Skills In House (C1), Satisfied of Employees (C2), User Friendly (C3),Adaptability (C4), Management Control (C5)*

Weakneses: Project Team Adaptability (C6), Proposed Schedule (C7), Training Requirements (C8)

Opportunites: *Trends (C9), requirements (C10)*

Threats: replacement of project team (C11), Testing (C12), Product Definition (C13)

Firstly we determine the weights of main and sub-criteria by using the fuzzy AHP. In first stage, the pairwise comparisons of main and sub-criteria are made by experts. The pairwise comparison matrix is shown in the Table 1-Table 5

TABLE 1. THE MAIN-CRITERIA PAIRWISE COMPARISON MATRIX

Comparison of main attribute	Strengths			Weakneses			Opportunites			Threats		
Strengths	1	1	1	4	5	6	2	3	4	2	3	4
Weaknesses	1/6	1/5	1/4	1	1	1	1/6	1/5	1/4	2	3	4
Opportunities	1/4	1/3	1/2	4	5	6	1	1	1	2	3	4
Threats	1/4	1/3	1/2	1/4	1/3	1/2	1/4	1/3	1/2	1	1	1

TABLE 2. THE SUB-CRITERIA OF STRENGTHS PAIRWISE COMPARISON MATRIX

sub attribute	C1			C2			C3			C4			C5	
C1	1	1	1	2	3	4	2	3	4	1/4	1/3	1/2	1/4	1/3	1/2
C2	1/4	1/3	1/2	1	1	1	1/6	1/5	1/4	1/6	1/5	1/4	1/6	1/5	1/4
C3	1/4	1/3	1/2	4	5	6	1	1	1	1/4	1/3	1/2	1/4	1/3	1/2
C4	2	3	4	4	5	6	2	3	4	1	1	1	2	3	4
C5	2	3	4	4	5	6	2	3	4	1/4	1/3	1/2	1	1	1

TABLE 3. THE SUB-CRITERIA OF WEAKNESSES PAIRWISE COMPARISON MATRIX

sub attribute	C6			C7			C8		
C6	1	1	1	1/6	1/5	1/4	1/4	1/3	1/2
C7	4	5	6	1	1	1	4	5	6
C8	2	3	4	1/6	1/5	1/4	1	1	1

TABLE 4. THE SUB-CRITERIA OF OPPORTUNITIES PAIRWISE COMPARISON MATRIX

sub attribute	C9			C10		
C9	1	1	1	1/4	1/3	1/2
C10	2	3	4	1	1	1

TABLE 5. THE SUB-CRITERIA OF THREATS PAIRWISE COMPARISON

sub attribute	C11			C12			C13		
C11	1	1	1	1/4	1/3	1/2	1/6	1/5	1/4
C12	2	3	4	1	1	1	1/4	1/3	1/2
C13	4	5	6	2	3	4	1	1	1

The pairwise comparison matrix of alternatives is shown in the Table 6-Table 13

TABLE 6. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE C1

Strengths-Experience Skills In House		Waterfall			Agile		
1	Waterfall	1	1	1	2	3	4
2	Agile	1/4	1/3	1/2	1	1	1

TABLE 7. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE -C2

Strengths-Satisfied of Employees		Waterfall			Agile		
1	Waterfall	1	1	1	1/6	1/5	1/4
2	Agile	4	5	6	1	1	1

TABLE 8. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE -C3

Strengths-User Friendly		Waterfall			Agile		
1	Waterfall	1	1	1	1/4	1/3	1/2
2	Agile	2	3	4	1	1	1

TABLE 9. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE -C4

Strengths-Adaptability		Waterfall			Agile		
1	Waterfall	1	1	1	1/4	1/3	1/2
2	Agile	2	3	1/4	1	1	1

TABLE 10. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE-C5

Strengths-Management Control		Waterfall			Agile		
1	Waterfall	1	1	1	1/4	1/3	1/2
2	Agile	2	3	4	1	1	1

TABLE 11. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C6

Project Team Adaptability		Waterfall			Agile		
1	Waterfall	1	1	1	4	5	6
2	Agile	1/6	1/5	1/4	1	1	1

TABLE 12. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C7

Proposed Schedule		Waterfall			Agile		
1	Waterfall	1	1	1	2	3	4
2	Agile	1/4	1/3	1/2	1	1	1

TABLE 13. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C8

Training Requirements		Waterfall			Agile		
1	Waterfall	1	1	1	4	5	6
2	Agile	1/6	1/5	1/4	1	1	1

TABLE 14. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C9

Trends		WaterFall			Agile		
1	WaterFall	1	1	1	1/6	1/5	1/4
2	Agile	4	5	6	1	1	1

TABLE 15. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C10

Requirements		Waterfall			Agile		
1	Waterfall	1	1	1	2	3	4
2	Agile	1/4	1/3	1/2	1	1	1

TABLE 16. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C11

Replace of project team		Waterfall			Agile		
1	Waterfall	1	1	1	2	3	4
2	Agile	1/4	1/3	1/2	1	1	1

TABLE 17. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C12

Testing		Waterfall			Agile		
1	Waterfall	1	1	1	1/8	1/7	1/6
2	Agile	6	7	8	1	1	1

TABLE 18. PAIRWISE COMPARISONS OF ALTERNATIVES WITH RESPECT TO SUB-ATTRIBUTE –C13

Product Definition		Waterfall			Agile		
1	Waterfall	1	1	1	2	3	4
2	Agile	1/4	1/3	1/2	1	1	1

After comparisons, the Buckley's fuzzy AHP methodology is applied and the criteria weights are calculated. The detailed results are shown in Table 19-Table 21.

ISBN: 978-988-19253-5-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE 19. THE CRITERIA WEIGHTS OF STRENGTHS FOUND BY FUZZY AHP

	Strengths														
	C1			C2			C3			C4			C5		
	0,106			0,031			0,076			0,270			0,177		
WaterFall	0,522	0,750	1,045	0,138	0,167	0,208	0,185	0,250	0,369	0,414	0,250	0,369	0,185	0,250	0,369
Agile	0,185	0,250	0,369	0,678	0,833	1,017	0,522	0,750	1,045	1,172	0,750	0,261	0,522	0,750	1,045
BEST NON-FUZZY NUMBER (BNP)-AGILE	0,268			0,843			0,772			0,728			0,772		
BEST NON-FUZZY NUMBER (BNP)-WATERFALL	0,772			0,171			0,268			0,345			0,268		

TABLE 20. THE CRITERIA WEIGHTS OF WEAKNESSES AND OPPORTUNITIES FOUND BY FUZZY AHP

	Weaknesses									Opportunities					
	C6			C7			C8			C9			C10		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
Fuzzy Weights of Main Attribute	0,077	0,115	0,176	0,077	0,115	0,176	0,077	0,115	0,176	0,189	0,292	0,462	0,189	0,292	0,462
Fuzzy Weights of Sub Attribute	0,072	0,097	0,140	0,525	0,701	0,928	0,144	0,202	0,281	0,185	0,250	0,369	0,522	0,750	1,045
Fuzzy Importance Degrees	0,006	0,011	0,025	0,040	0,081	0,163	0,011	0,023	0,049	0,035	0,073	0,171	0,099	0,219	0,483
BEST NON-FUZZY NUMBER (BNP)	0,014			0,095			0,028			0,093			0,267		

TABLE 21. THE CRITERIA WEIGHTS OF THREATS FOUND BY FUZZY AHP

	Threats								
	C11			C12			C13		
	L	M	U	L	M	U	L	M	U
Fuzzy Weights of Main Attribute	0,056	0,086	0,148	0,056	0,086	0,148	0,056	0,086	0,148
Fuzzy Weights of Sub Attribute	0,075	0,105	0,159	0,171	0,258	0,401	0,431	0,637	0,919
Fuzzy Importance Degrees	0,004	0,009	0,024	0,010	0,022	0,059	0,024	0,055	0,136
BEST NON-FUZZY NUMBER (BNP)	0,012			0,030			0,071		

If an attribute on the left is more important than the one matching on the right, put your check mark to the left of the importance ‘‘equal’’ under the importance level you prefer. If an attribute on the left is less important than the one matching on the right, put your check mark to the right of the importance ‘Equal’ under the importance level you prefer.

The results of evaluating alternatives are shown in Table 22-Table 25.

TABLE 22. EVALUATION OF ALTERNATIVES FOR STREBGTHS

	Strengths														
	C1			C2			C3			C4			C5		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
FUZZY WEIGHTS OF MAIN ATTRIBUTE	0,318	0,507	0,777	0,318	0,507	0,777	0,318	0,507	0,777	0,318	0,507	0,777	0,318	0,507	0,777
FUZZY WEIGHTS OF SUB ATTRIBUTE	0,094	0,156	0,269	0,032	0,048	0,077	0,071	0,111	0,192	0,247	0,416	0,670	0,094	0,156	0,269
FUZZY IMPORTANCE DEGREES	0,030	0,079	0,209	0,010	0,024	0,060	0,023	0,056	0,149	0,078	0,211	0,520	0,030	0,079	0,209
BEST NON-FUZZY NUMBER (BNP)	0,106			0,031			0,076			0,270			0,177		

ISBN: 978-988-19253-5-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE 23. EVAULATION OF ALTERNATIVES FOR WEAKNESES

	Threats								
	C11			C12			C13		
	0,012			0,030			0,071		
WaterFall	0,522	0,750	1,045	0,109	0,125	0,146	0,522	0,750	1,045
Agile	0,185	0,250	0,369	0,757	0,875	1,009	0,185	0,250	0,369
BEST NON-FUZZY NUMBER (BNP)-AGILE	0,268			0,880			0,268		
BEST NON-FUZZY NUMBER (BNP)-WATERFALL	0,772			0,127			0,772		

TABLE 24. EVALUATION OF ALTERNATIVES FOR OPPORTUNITIES

	Weakneses								
	C6			C7		C8			
	0,014			0,095		0,028			
WaterFall	0 , 522	0 , 750	1 , 045	0 , 522	0 , 750	1 , 045	0 , 678	0 , 833	1 , 017
Agile	0,185	0, 250	0,369	0, 185	0 250	0,369	0, 138	0,167	0,208
BEST NON-FUZZY NUMBER (BNP) - AGILE	0,268			0,268		0,171			
BEST NON-FUZZY NUMBER (BNP)-WATERFALL	0,772			0,772		0,843			

TABLE 25. EVALUATION OF ALTERNATIVES FOR THREATS

	Opportunities					
	C9			C10		
	0,093			0,267		
Waterfall	0,138	0,167	0,208	0,522	0,750	1,045
Agile	0,678	0,833	1,017	0,185	0,250	0,369
BEST NON-FUZZY NUMBER (BNP)-AGILE	0,843			0,268		
BEST NON-FUZZY NUMBER (BNP)-WATERFALL	0,171			0,772		

According to results, Agile which has the highest value with 0,68 is selected as the most appropriate project management methodology.

IV. CONCLUSION

Project management methodology is very important for IT Departments. In this study, we have presented multi criteria decision making problems based on fuzzy sets by combining SWOT with AHP techniques to select the most effective project management methodology for software development department in an international bank. Two-stage fuzzy decision making technique has been used for the decision. In the first stage, criteria have been defined using SWOT. In the second stage the most effective project management methodology, Agile, has been selected by applying weighted fuzzy AHP.

REFERENCES

[1] Helander M. G., Lin L.,"Axiomatc design in ergonomics and an extension of the information axiom", Journal of Engineering Design, Vol. 13, No: 4, pp. 321–339, 2002.

[2] Önüt, S., Tuzkaya, U.R. ve Kemer, B., "An Analytical Network Process Approaach to the Choice of Hospital", Sigma Journal of Engineering and Natural Sciences, Vol. 25, Issue 4, pp. 367-379,2008

[3] Strode, D. E., Huff, S. L., Hope, B. and Link, S., "Coordination in co-located agile software development projects", The Journal of Systems and Software, Vol:85, pp. 1222– 1238, 2012

[4] Bryson, J.M, Roaring,. W.D. , "Applying private sector strategic planning in the public sector ",Journal of the American Planning Association, 53, pp. 9–22, 1987.

[5] European Commission, Evaluating socio-economic programmes. Principal evaluation techniques and tools. MEANS-collection, vol. 3 European Communities, Luxembourg, 1999.

[6] Karppi, I., Kokkonen, M., Lähteenmäki-Smith, K., "SWOT-analysis as a basis for regional strategies", Nordregio Working Paper 2001, vol. 4 Nordregio – the Nordic Centre for Spatial Development, Stockholm, Sweden ,2001.

[7] Markovska, N., Taseska, V., Pop-Jordanov, J., "SWOT analyses of the national energy sector for sustainable energy development", Energy 34 , pp. 752–756, 2009.

[8] Harrison, J. "Essentials of Strategic Planning in Healthcare", Chapter 5: Strategıc Plannıng And Swot Analysıs, Health Administration Press, 2010.

[9] Kotler, P. "Marketing Management: Analysis, Planning, Implementation and Control", (sixth ed.)Prentice-Hall International Edition, 1988.

[10] Wheelen, T.L., Hunger, J.D., "Strategic Management and Business Policy", (fifth ed.)Addison Wesley, Reading, MA,1995.

[11] Kajanus,M., Leskinen, P., Kurttila,M., Kangas, J., "Making use of MCDS methods in SWOT analysis—Lessons learnt in strategic natural resources management", Forest Policy and Economics, 2012.

[12] Leskinen, L.A., Leskinen P., Kurttila M., Kangas J., and Kajanus M. , "Adapting modern strategic decision support tools in the participatory strategy process- a case study of a forest research station", Forest Policy and Economics, Vol. 8, pp. 267-278, 2006.

[13] Pasonen, M., Kurtilla, M., Kangas, J., Kajanus, M., Heinonen, P., "Assesing the priorities A'WOT among resource management strategies at the Finish forest and park service", Forest Science, Vol. 47, No. 4, pp. 534-541, 2000.

[14] Masozera, M.K., Alavalapati J.R.R., Jacobson S.K., and Shrestha R.K., "Assessing the suitability of community-based management for the Nyungwe Forest Reserve", Rwanda. Forest Policy and Economics, Vol. 8, pp. 206-216, 2006.

[15] Kajanus, M., Kangas J., and Kurttila M. Shrestha, R.K., Alavalapti, J.R.R., and Kalmbacher, R.S. "Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT-AHP method", Agriculture Systems, Vol. 81, pp. 185-199, 2004.

[16] Stewart R.A., Mohamed, S., and Daet, R." Strategic implementation of IT/IS projects in construction: a case study", Automation in Construction, vol. 11, pp. 681-694, 2002.

[17] Chan, P. S.;Heide, D., "Information Technology and the New Environment: Developing and Sustaining Competitive Advantage", Advanced Management Journal ,1992.

ISBN: 978-988-19253-5-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

[18] Rousan, M., "The Impact of SWOT Analysis on Achieving a Competitive Advantage: Evidence from Jordanian Banking Industry ", International Bulletin of Business Administration , ISSN: 1451-243X Issue 6, 2009.
[19] Şeker, Ş., Özgürler, M., "Analysis of The Turkish Consumer Electronics Firm Using SWOT-AHP Method", Procedia - Social and Behavioral Sciences, 8th International Strategic Management Conference, Volume 58, 12, pp. 1544–1554, 2012.
[20] T.Y. Hsieh, S.T. Lu, G.H. Tzeng, "Fuzzy MCDM approach for planning and design tenders selection in public office buildings", International Journal of Project Management 22, pp. 573-584, 2004.
[21] Kayikci, Y., "A conceptual model for intermodal freight logistics centre location decisions", Procedia Social and Behavioral Sciences, 2, pp. 6297-6311, 2010.

ISBN: 978-988-19253-5-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)