2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE)
July 6-11, 2014, Beijing, China

The Prioritization for Higher Education Institutions Performance Criteria with Fuzzy Analytical Hierarchy Process

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Abstract— This research is an investigation of criteria for making a decision of quality in the higher education institutions. The multi-criteria decision was used to achieve the progressive of quality in the university. Fuzzy Analytical Hierarchy Process (FAHP) is applied for these multi-criteria to select the highest prioritizing criteria for achieving the goal of quality institution which can tolerate vagueness and uncertainty of human judgment. The hierarchy consists of 9 main criteria and 44 sub-criteria, recognized by Office of the Higher Education Commission Ministry of Education Thailand, correspond with those main criteria and 6 alternatives from the experts under each sub-criterion. The sensitivity analysis has made by changing the membership function, from triangular membership function to trapezoidal membership function, the studied also changed membership number. However the result of this hypothesis has shown that none of functions variation has impacted the main criteria and alternative. The comparison of preference score and priority of each criterion between FAHP and AHP has the same results.

I. Introduction

Due to the highly growth of the economic over the past decade, many new born higher education institutes including government and private university and college has established in many areas of Thailand. Especially, in the Northern of Thailand only in Chiangmai province, there were just about 12 universities which have educated over 440,000 students [1]. The following question is how the quality and efficiency of educational for those institutes should be. For the objectives of the higher education institutions in Thailand, there are 4 main missions: to produce graduates, to conduct research studies, to provide academic services to the society and to preserve art and culture. Then, the quality assurance system is needed for higher education institutions to succeed in these missions. Leading for external peers every five year assess the education quality of the institute. Meanwhile, self-assessment was encouraged within many institutes to be responsibility for quality. In general, there are 9 main criteria and 44 sub-criteria for measuring the education quality recognized by the Office of the Higher Education Commission, Ministry of Education Thailand. Even if the scoring of the main criteria and sub-criteria are equal, in practice these criteria are different significant. In this paper, we adopted these criteria to achieve the goal of quality in education. To achieve the goal, all of criteria required to prioritize by weighting the score which can be done either by the expert and administrator.

Multi Criteria Decision Making (MCDM) is one of the techniques which can be applied in better way to decide ranking of the criteria. Since almost the criteria mentioned above are qualitative hence fuzzy theory is used to help. One of the most popular analytical techniques for complex decision-making problem is the analytic hierarchy process (AHP).Analytic Hierarchy Process (AHP) is proposed by Satty (1980) [2], is an approach for decision making that involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. The output of the AHP is prioritized ranking indicating the overall preference for each of the decision alternatives eventually help the decision maker to select the best approach. The FAHP method is an advanced analytical method which is developed from the AHP. In spite of the popularity of AHP, this method is often criticized for its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the decision-makers perception to exact numbers. In FAHP method, the fuzzy comparison ratios are used to be able to tolerate vagueness. Decision maker wants to use the uncertainty while performing the comparisons of the alternatives. For taking uncertainties into consider ration fuzzy numbers are used instead of crisp numbers.

To deal with vagueness of human thought, Zadeh [3] first introduced the fuzzy set theory, which was oriented to the rationality of uncertainty. A major contribution of fuzzy set theory is its capability of representing vague data. A fuzzy set is a class of objects with a membership function ranging between zero and one. It was specifically designed to mathematically represent uncertainty and vagueness. Fuzzy set theory implements groupings of data with boundaries that are not sharply defined (i.e. fuzzy). Any methodology or theory implementing "crisp" definitions such as classical set theory, arithmetic, and programming, may be "fuzzified" by generalizing the concept of a crisp set to a fuzzy set with blurred boundaries. The benefit of extending crisp theory and analysis methods to fuzzy techniques is the strength in solving real-world problems, which inevitably entail some degree of imprecision in the variables and parameters measured and processed for the application [4]. A triangular fuzzy number (TFN) is the special class of fuzzy number whose membership is defined by three real numbers,

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This work was supported by the Research Institute of North-Chiangmai University.

expressed as (*l, m, u*). The triangular membership function is represented as follows [5].

$$triangular(x:a,b,c)=\begin{cases}0 & ,x<a\\ (x-a)/(b-a) & ,a\le x\le b\\ (c-x)/(c-b) & ,b\le x\le c\\ 0 & ,x>c\end{cases} \quad (1)$$

The operational laws between two triangular fuzzy numbers $M_1=(l_1, m_1, u_1)$ and $M_2=(l_2, m_2, u_2)$ are as follows

$$M_1 \oplus M_2 = (l_1+l_2,\ m_1+m_2,\ u_1+u_2) \quad (2)$$

$$M_1 \otimes M_2 = (l_1 l_2,\ m_1 m_2,\ u_1 u_2) \quad (3)$$

$$M_1^{-1} = (1/u_1,\ 1/m_1,\ 1/l_1) \quad (4)$$

The conventional AHP method is incapable of handling the uncertainty and vagueness involved in the mapping of one's preference to an exact number or ratio. The major difficulty with classical AHP is its inability in mapping human judgments. In recent years it has been observed that due to confusion in decision makers mind probable deviations should be integrated to the decision making process [6]. In Fuzzy-AHP, pair wise comparisons are done using fuzzy linguistic preference scale ranging from 0 to 10. For simplicity, the reciprocal fuzzy numbers are replaced by individual TFN's in the pair wise comparison matrix [7].

Among the different methodologies used, it has been observed that Fuzzy-AHP method was used extensively in decision making e.g. selection the best bridge construction method among the alternatives avoiding the inconsistency [7], selection the best technical college in India [8], assess the quality of knowledge in knowledge management systems in the context of institutions of Thailand higher education [9], formulate and prioritize the intellectual capital model for assessing their performance contribution in a university [10], and etc. In order to develop a Fuzzy-AHP decision making model for the prioritization of criteria and alternatives, the piece of work is organized as follows. In the next section, the methodology is introduced along with the stages of development of the model. After that results and discussion are expressed. Finally, the paper ends with the conclusion.

II. Materials and Methods

A. Conceptual Hierarchy of Fuzzy–AHP model

Analytical Hierarchy Process starts by laying out the overall hierarchy of the decision making problem. The hierarchy is structured from the top (the overall goal of the problem) through the intermediate levels (criteria and sub-criteria on which subsequent levels depend) to the bottom level (the list of alternatives). Each criterion in the lower level of hierarchy is compared with respect to the criteria in the upper level of hierarchy. The criteria in the same level are compared using pair wise comparison. Fig 1 describes the hierarchy of our decision making problem by set the goal of the problem is the Quality of Educational institution, the 9 main criteria and 44 sub-criteria in the intermediate levels were adopted the from Ministry of education, and the 6 alternatives were obtained by the experts.

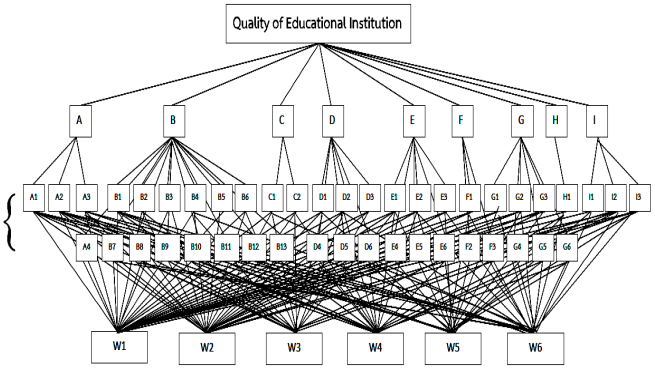

Fig 1. Detailed hierarchy of the problem.

B. Fuzzy pair wise comparison method

ANFIS Once the hierarchy is established, the pair wise comparison evaluation takes place. All the criteria on the same level of the hierarchy are compared to each of the criterion of the preceding (upper) level. A pair wise comparison is performed by using Fuzzy linguistic terms in the scale of 1-9 described by the Triangular Fuzzy Numbers in the Table 1.

Table 1 Fuzzy Importance scale with TFN.

Fuzzy Number	Verbal judgment	TFN
1	Preference level	(1,1,1)
2	Equally Preferred	(1,2,3)
3	Equally to Moderately Preferred	(2,3,4)
4	Moderately Preferred	(3,4,5)
5	Moderately to Strongly Preferred	(4,5,6)
6	Strongly Preferred	(5,6,7)
7	Strongly to Very strongly Preferred	(6,7,8)
8	Very Strongly Preferred	(7,8,9)
9	Very Strongly to Extremely Preferred	(8,9,9)

To reflect pessimistic, most likely and optimistic decision making environment, triangular fuzzy numbers with minimum value, most plausible value & maximum value are considered. Here the fuzzy comparison matrix is defined as

$$A=\begin{array}{c} criteria \\ \\ A_1\\ A_2\\ A_3\\ \vdots\\ A_n\end{array}\begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & \dots & C_n & factor \end{array}\\ \begin{bmatrix} 1 & \tilde{a}_{12} & \tilde{a}_{13} & \dots & \tilde{a}_{1n}\\ 1/\tilde{a}_{12} & 1 & \tilde{a}_{23} & \dots & \tilde{a}_{2n}\\ 1/\tilde{a}_{13} & 1/\tilde{a}_{23} & 1 & \dots & \tilde{a}_{3n}\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & 1/\tilde{a}_{3n} & \dots & 1 \end{bmatrix}\end{array}$$

Where $a_{ij}=\left(\tilde{a}_{ij}^{L},\tilde{a}_{ij}^{M},\tilde{a}_{ij}^{U}\right)$ is the relative importance of each criteria in Pair wise comparison and $\tilde{a}_{ij}^{L},\tilde{a}_{ij}^{M},\tilde{a}_{ij}^{U}$ are the minimum value, most plausible value & maximum value of the triangular fuzzy number. To simplify the calculation of

element weight the fuzzy pair wise comparison matrix is broken into crisp matrices formed by taking the minimum values, most plausible values & maximum values from the triangular fuzzy numbers.

C. Generation of Criteria and Sub-Criteria weight

The Normalization of the Geometric Mean (NGM) method (Buckley et al, 1985) is applied to compute weights from the fuzzy pair wise comparison matrices which is given by

$$w_i = \left(a_i / \sum_{i=1}^{n} a_i \right) \quad (5)$$

Where

$$a_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{1/n}$$

In the above equations, a_i is geometric mean of criterion i. a_{ij} is the comparison value of criterion i to criterion j. w_i is the i^{th} criterion's weight, where $w_i > 0$ and $\sum_{i=1}^{n} w_i = 1$. For group evaluation, it is required to aggregate evaluator's opinions into one. Considering the evaluation given by expert $Ei = (a_L^{(i)}, a_M^{(i)}, a_U^{(i)})$ the aggregate of all experts' judgments can be calculated using average means

$$\tilde{A} = \left(\frac{1}{n}\sum_{i=1}^{n} a_L^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_M^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_U^{(i)} \right) \quad (6)$$

The final weight vector is generated by defuzzifying the average [11]

$$w_{(i)} = \left(\frac{1}{n}\sum_{i=1}^{n} a_L^{(i)} + 2\left(\frac{1}{n}\sum_{i=1}^{n} a_M^{(i)} \right) + \frac{1}{n}\sum_{i=1}^{n} a_U^{(i)} \right) \Big/ 4 \quad (7)$$

The weight of i^{th} sub-criteria under k^{th} main criteria is obtained by $w_k \times S_{ki}$ where w_k is the k^{th} main criteria weight and S_{ki} is the weight of i^{th} sub criteria with respect to k^{th} main criteria.

D. Calculation of overall score for alternatives

Once the weight of criteria, sub criteria are evaluated and are multiplied using equation (3) to obtain global weight of sub-criteria, it is required to calculate the overall score of alternatives for their evaluation. The overall score of m^{th} alternative is obtained by

$$A_m = \sum_{l}^{N} s_l \times a_{ml} \quad (8)$$

where S_l is the weight of l^{th} sub-criteria and a_{ml} is the weight of m^{th} alternative with respect to l^{th} sub-criteria.

E. Identification of Criteria and Sub Criteria for evaluating alternatives

One of the important steps of the proposed model is to determine all the important criteria and their relationship with the decision variables. This step is crucial because the selected criteria and sub criteria can influence the final choice. For our research, the criteria and sub-criteria are selected based on the format mentioned by Office of the Higher Education Commission Ministry of Education Thailand. The 6 alternatives taken are the prioritized factors: Teacher quality (W1), Administrative, Research (W2), Teaching Learning Process (W3), Academic Service (W4), and Student (W5). The criteria and sub-criteria selected are described in Table 2.

F. Sensitivity analysis

For testing with the sensitivity analysis, in this research two methods (change the shape from triangular membership function to trapezoidal membership function and extend/stretch the TFN) were applied. . A pair wise comparison is performed by using Fuzzy linguistic terms in the scale of 1-9 described by the Trapezoidal Fuzzy Numbers in the Table 3. Triangular Fuzzy Number is extended up/stretched down by number 0.5 and expressed in Table 4.

Table 3 The trapezoidal membership function number.

Fuzzy Number	Trapezoidal Fuzzy Number (TFN)
1̃	(1,1,1,1)
2̃	(1,1,5,2.5,3)
3̃	(2,2.5,3,5,4)
4̃	(3,3.5,4.5,5)
5̃	(4,4.5,5.5,6)
6̃	(5,5.5,6.5,7)
7̃	(6,6.5,7.5,8)
8̃	(7,7.5,8.5,9)
9̃	(8,8.5,9,9)

Table 4 Extend/stretch the triangular membership function by number 0.5.

Fuzzy Number	TFN	Extend	Stretch
1̃	(1,1,1)	(1,1,1)	(1,1,1)
2̃	(1,2,3)	(1,2,3.5)	(1.5,2,2.5)
3̃	(2,3,4)	(1.5,3,4.5)	(2.5,3,3.5)
4̃	(3,4,5)	(2.5,4,5.5)	(3.5,4,4.5)
5̃	(4,5,6)	(3.5,5,6.5)	(4.5,5,5.5)
6̃	(5,6,7)	(4.5,6,7.5)	(5.5,6,6.5)
7̃	(6,7,8)	(5.5,7,8.5)	(6.5,7,7.5)
8̃	(7,8,9)	(6.5,8,9)	(7.5,8,8.5)
9̃	(8,9,9)	(7.5,9,9)	(8.5,9,9)

III. Results and Discussion

The detail of the steps of Fuzzy-AHP model described in section 2 is explained elaborately using the data collected from the questionnaire filled in by the experts.

llustration of the Fuzzy-AHP model

Once the hierarchy was established and a series of questions were asked to direct pair wise comparisons, each expert performed a pair wise comparison. Hence the main criteria weights from all experts' judgments following equation (5) can be expressed on second column in Table 5. The results indicate that the priority of "Graduate Production (B)" is the highest followed by "Research (D)". Following the same procedure the weights of the sub-criteria are calculated

and the results are also described on column 4 in Table 5. Further the sub-criteria weights are multiplied by the corresponding main criteria weights to obtain global weight of the sub-criteria as on column 5 in Table 5. The results of the global sub-criteria weights indicate that the priorities are highest in System and mechanism for finance and budgeting (H1) followed by Plan development process (A1).

From the main and sub-criteria weights in the table 5 is can be inferred that there exists variation between the priorities of the main and sub criteria mentioned in the model. It is further observed that in case of sub-criteria the priority is highest for "Plan development process (A1)" under "Philosophy, Commitments, Objectives, and Implementation Plans (A)", "System and mechanisms for curriculum development and administration (B1)" under "Graduate Production (B)", "System and mechanisms to promote student activities (C2)" under "Student Development Activities (C)", "Research or creative to make a useful (D5)" under "Research (D)"," Learning result and reinforcement of the community (E4)" under "Academic Services to the Community (E)", "System and mechanism for the preservation of arts and culture (F1)" under "Preservation of Arts and Culture (F)" under "Preservation of Arts and Culture (F)", "Leadership of the institution council and administrators at all levels of the institution (G1)" under "Administration and Management (G)", "System and mechanism for finance and budgeting (H1)" under "Finance and Budgeting (H)", and "System and mechanism for internal quality assurance (I1)" under "System and Mechanism for Quality Assurance (I)".

The six alternative factors for the quality of educational institutions which were analyzed from the expert are collected with respect to each of the sub-criteria using Fuzzy linguistic preference scale and the corresponding weights are generated as described on the rest columns in Table 5. Fuzzy Score of 6 alternatives along with the final crisp score and consistency ratio (C.R.) are expressed in table 6. It is found that "Teacher quality (W1)" has the high score followed by "Administrative (W2)".

Sensitivity analysis discussions

The sensitivity analysis is made to measure the reliable of the method. For the first test, the Trapezoidal membership function is replaced the Triangular membership function by the same scale. The results of the weight value and ranking on main criteria and alternatives for this test are shown in table 7 and table 8 respectively. Both of membership functions obtained the same results in criteria ranking. The C.R. of each alternative is less than 0.1 means that the pair wise comparison has the reliable. The second test, the TFN is extended/stretched by the number 0.5. The results of the weight value and ranking on main criteria and alternatives for this test are shown in table 9 and table 10 respectively. Both of them obtained the same results in criteria ranking.

The comparison between FAHP with AHP

The results from FAHP have compared with the original AHP to check the stability of the method. The comparisons of main criteria and alternative weight ranking are expressed in table 11 and table 12 respectively. Both have obtained the same results in criteria ranking.

IV. Conclusion

Since, there are many new born higher institutions including government and private institution have established in Thailand. Lots of them have emerged with a business orientation offering readymade courses. Few of them are truly worthy and offering quality education but many of them are managing with the quality. To reinforce the quality institution, the criteria collected from Ministry of Education of Thailand must be prioritized in order to develop in efficiency way. This paper adopts a Fuzzy-AHP model to solve the problem in ranking the criteria. In this model Triangular Fuzzy numbers are utilized in collecting expert judgments through linguistic variables. Further Analytical Hierarchy Process was used in generating criteria weights and sub criteria weights for the evaluation of alternatives.

The results from computation show that the priority of "***Graduate Production***" and "***Research***" are the highest criteria which are selected to develop first more than the other. Priority of "Teacher quality" and "Administrative" are the highest alternatives to achieve the goal of quality institution. Further this study is not limited to the prioritizing the criteria for quality institution; rather it can be used in multi-criteria decision making in any field of study.

Acknowledgment

The authors would like to gratefully thank the research institute of North-Chiangmai University for the support of this project. The author also thank to anonymous referees for useful suggestions and a constructive critique.

References

[1] R.R. Yager, L.A. Zadeh "Fuzzy sets, neural networks and soft computing," *Van Nostrand Reinhold*, New York, 1994.

[2] Chiangmai government complex, site 24 Jan 2012. www.th.wikipedia.org/wiki/จังหวัดเชียงใหม่

[3] Thomas L. Saaty, The Analytic Hierarchy Process, New York: McGraw-Hill, 1980.

[4] Zadeh, L.A, Fuzzy sets, Information and control, 8, 338-353, 1965

[5] B. Pang, "Multi-criteria Supplier Evaluation Using Fuzzy AHP", *Proceedings of the IEEE Inter. Conference on Mechatronics and Automation*, August, Harbin, China, 5 - 8, 2007.

[6] T. Moon, W.B. Lee, "Construction Of Supporting System For Decision Making Process Of Zoning Designation and Change That has Fuzziness", *The 6th International Conference Computers in Urban Planning and Urban Managemen*, 1999.

[7] A. Ozdagoglu, G. Ozdagoglu, "Comparison of AHP and Fuzzy AHP for the multicriteria decision making processes with linguistic evaluations", Ýstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi, 6, 65-85, 2007.

[8] Pan, N.F, "Fuzzy AHP approach for selecting the suitable bridge construction method", *Automata in construction*, 17, 958-965, 2008.

[9] D. Chattrfee, et. al., "Study of Fuzzy-Ahp Model to Search the Criterion in the Evaluation of the Best Technical Institutions: A Case Study," *Int. J. of Eng. Sci. and Tech*., Vol. 2(7), pp. 2499-2510, 2010.

[10] C. Tongchuay and P. Praneetpolgrang ,"Application of Fuzzy Logic in Knowledge Quality Assessment for Knowledge Management Systems in the Context of Institutions of Higher Education," *J. of Inf. Sci. and Tech.*, vol. 1, pp. 43-53, Jan-Jun 2010.

[11] S.H. Lee, "Using Fuzzy AHP to Develop Intellectual Capital Evaluation Model for Assessing Their Performance Contribution in a University," *J. Expert Sys. with App.*, pp. 4941-4947, 2009.
[12] F. Mehdi, "The fuzzy evaluation of E-Commerce customer satisfaction", *world appl. Sc. journal* 4(2), 164-168, 2008.

Table 2 Criteria and sub-criteria

Criteria	Sub-criteria
Philosophy, Commitments, Objectives, and Implementation Plans (A)	A1 Plan development process
	A2 Results of institute development by (A)
	A3 Results of graduate student reach for identity
	A4 Results on the focus and dominant reflect the identity of institute
Graduate Production (B)	B1 System and mechanisms for curriculum development and administration
	B2 Full-time instructors holding doctoral degrees
	B3 Full-time instructors holding academic titles
	B4 System for faculty and supporting personnel development
	B5 Library, educational equipment, and learning environment
	B6 System and mechanisms for teaching and learning management
	B7 System and mechanism for developing educational achievements according to graduates' qualifications
	B8 Success rate in reinforcing moral and ethical character traits in students
	B9 Graduate has a job or freelance within a year
	B10 Bachelor, Master, Doctoral student quality according to qualification of Office of the higher education commission
	B11 A success of Master degree published or propagated
	B12 A success of Doctoral degree published or propagated
	B13 Teacher development
Student Development Activities (C)	C1 System and mechanism to provide guidance and information services
	C2 System and mechanism to promote student activities
Research (D)	D1 System and mechanism to develop research and creative work
	D2 System and mechanism to manage the knowledge gained from research or creative work
	D3 Funds for research or creative work per full-time faculty/researcher
	D4 Research or creative work to published or propagated
	D5 Research or creative work to utilize
	D6 Academic research under quality assurance
Academic Services to the Community (E)	E1 System and mechanism for academic services to community
	E2 Process of academic services to benefit community
	E3 Result after apply knowledge and experience from academic services to community into faculty/research development
	E4 Learning and reinforcement results of community or organization
	E5 Guidance, prevention, or problem solving results of community for first part inside institution
	E6 Guidance, prevention, or problem solving results of community for first part outside institution
Preservation of Arts and Culture (F)	F1 System and mechanism for preservation of arts and culture
	F2 Reinforcement and supporting of arts and culture
	F3 Development of aesthetic in art and culture prospect
Administration and Management (G)	G1 Leadership of the institution council and administrators at all levels of the institution
	G2 Institutional development towards becoming a learning
	G3 Information system for administration and decision-making
	G4 Risk management system
	G5 Comply with the role of institute council
	G6 Comply with the role of institute administration
Finance and Budgeting (H)	H1 System and mechanism for finance and budgeting
System and Mechanism for	I1 System and mechanism for internal quality assurance

Quality Assurance (I)	I2 Assessment quality assurance guarantee by original affiliation
	I3 Indication increase by identity of institution "Student development on satisfy"

Table 5 Global weight of criteria and sub-criteria and alternative weight correspond with each sub-criterion.

Main Criteria	Weight	Sub-criteria	Weight	Net weight	Alternative					
					W1	W2	W3	W4	W5	W6
A	0.1269	A1	0.5314	0.0674	0.38	0.18	0.08	0.19	0.10	0.07
		A2	0.2081	0.0264	0.31	0.23	0.15	0.15	0.10	0.07
		A3	0.1443	0.0183	0.30	0.19	0.14	0.19	0.10	0.10
		A4	0.1211	0.0154	0.14	0.15	0.13	0.19	0.15	0.24
B	0.2495	B1	0.1551	0.0387	0.28	0.23	0.16	0.15	0.10	0.08
		B2	0.0557	0.0139	0.33	0.22	0.18	0.12	0.08	0.07
		B3	0.0608	0.0152	0.39	0.22	0.13	0.11	0.09	0.06
		B4	0.0835	0.0208	0.40	0.21	0.13	0.13	0.07	0.07
		B5	0.0335	0.0084	0.23	0.24	0.17	0.17	0.10	0.09
		B6	0.0806	0.0201	0.30	0.22	0.16	0.15	0.09	0.08
		B7	0.1211	0.0302	0.27	0.22	0.16	0.17	0.10	0.09
		B8	0.0535	0.0133	0.13	0.16	0.12	0.20	0.16	0.24
		B9	0.0653	0.0163	0.28	0.23	0.15	0.16	0.09	0.09
		B10	0.0943	0.0235	0.33	0.22	0.17	0.13	0.09	0.07
		B11	0.0573	0.0143	0.29	0.20	0.18	0.15	0.09	0.10
		B12	0.0626	0.0156	0.34	0.17	0.19	0.15	0.09	0.07
		B13	0.0835	0.0208	0.36	0.23	0.15	0.12	0.09	0.06
C	0.0760	C1	0.3389	0.0258	0.32	0.23	0.14	0.14	0.08	0.09
		C2	0.6621	0.0503	0.28	0.24	0.15	0.14	0.10	0.09
D	0.2072	D1	0.1748	0.0362	0.29	0.21	0.18	0.13	0.11	0.08
		D2	0.1948	0.0404	0.24	0.21	0.17	0.10	0.08	0.20
		D3	0.1345	0.0279	0.29	0.22	0.19	0.13	0.11	0.08
		D4	0.1537	0.0318	0.28	0.24	0.18	0.12	0.10	0.08
		D5	0.2092	0.0433	0.27	0.21	0.23	0.11	0.10	0.07
		D6	0.1397	0.0289	0.33	0.22	0.20	0.11	0.09	0.05
E	0.0491	E1	0.0994	0.0049	0.31	0.23	0.16	0.13	0.12	0.06
		E2	0.1813	0.0089	0.28	0.24	0.18	0.12	0.11	0.07
		E3	0.1697	0.0083	0.28	0.21	0.16	0.14	0.12	0.09
		E4	0.2449	0.0120	0.13	0.24	0.14	0.13	0.24	0.13
		E5	0.1683	0.0083	0.13	0.24	0.14	0.13	0.24	0.13
		E6	0.1521	0.0075	0.13	0.19	0.19	0.14	0.22	0.14
F	0.0598	F1	0.5189	0.0310	0.07	0.25	0.10	0.12	0.27	0.20
		F2	0.3126	0.0187	0.09	0.34	0.13	0.13	0.15	0.17
		F3	0.1794	0.0107	0.10	0.33	0.12	0.11	0.13	0.21
G	0.1095	G1	0.2534	0.0277	0.24	0.35	0.14	0.12	0.09	0.07
		G2	0.1725	0.0189	0.13	0.25	0.14	0.15	0.15	0.18
		G3	0.1447	0.0158	0.29	0.26	0.15	0.13	0.10	0.07
		G4	0.1016	0.0111	0.32	0.29	0.16	0.11	0.07	0.05
		G5	0.1029	0.0113	0.29	0.21	0.18	0.13	0.11	0.08
		G6	0.2278	0.0249	0.24	0.21	0.17	0.10	0.08	0.20
H	0.1085	H1	1.0000	0.1085	0.29	0.22	0.19	0.13	0.11	0.08
I	0.0187	I1	0.6301	0.0118	0.28	0.24	0.18	0.12	0.10	0.08
		I2	0.2572	0.0048	0.27	0.21	0.23	0.11	0.10	0.07
		I3	0.1193	0.0022	0.33	0.22	0.20	0.11	0.09	0.05

Table 6 Global weight of alternatives with consistency ratio (C.R.).

Alternative	Weight	C.R.
W1 (Teacher quality)	0.2727	0.0823
W2 (Administrative)	0.2475	0.0627
W3 (Research)	0.1512	0.0528
W4 (Teaching Learning Process)	0.1368	0.1003
W5 (Academic Service)	0.1087	0.0938
W6 (Student)	0.0981	0.0535

Table 7 The sensitivity analysis of main criteria weight ranking by changing the membership function from Triangular to Trapezoidal function.

Main Criteria	TFN		TrFN	
	Weight	Rank	Weight	Rank
Graduate Production (B)	0.3226	1	0.3090	1
Research (D)	0.3202	2	0.3068	2
Academic Services to the Community (E)	0.0970	3	0.0892	3
Philosophy, Commitments, Objectives, and Implementation Plans (A)	0.0816	4	0.0747	4
Administration and Management (G)	0.0714	5	0.0659	5
Finance and Budgeting (H)	0.0549	6	0.0504	6
Student Development Activities (C)	0.0509	7	0.0473	7

System and Mechanism for Quality Assurance (I)	0.0369	8	0.0342	8
Preservation of Arts and Culture (F)	0.0234	9	0.0223	9

Table 8 The sensitivity analysis of sub-criteria weight ranking by changing the membership function fromTriangular to Trapezoidal function.

Alternative	TFN		TrFN	
	Weight	Rank	Weight	Rank
W1 (Teacher quality)	0.2727	1	0.2495	1
W2 (Administrative)	0.2475	2	0.2452	2
W3 (Research)	0.1512	3	0.1448	3
W4 (Teaching Learning Process)	0.1368	4	0.1333	4
W5 (Academic Service)	0.1087	5	0.1194	5
W6 (Student)	0.0981	6	0.1078	6

Table 9 The sensitivity analysis of main criteria weight ranking by extending/stretching the Triangular membership function up/down by the number 0.5.

Main Criteria	TFN		Stretch		Extend	
	Weight	Rank	Weight	Rank	Weight	Rank
Graduate Production (B)	0.3226	1	0.3118	1	0.3459	1
Research (D)	0.3202	2	0.3093	2	0.3425	2
Academic Services to the Community (E)	0.0970	3	0.0927	3	0.1049	3
Philosophy, Commitments, Objectives, and Implementation Plans (A)	0.0816	4	0.0774	4	0.0903	4
Administration and Management (G)	0.0714	5	0.0676	5	0.0797	5
Finance and Budgeting (H)	0.0549	6	0.0517	6	0.0622	6
Student Development Activities (C)	0.0509	7	0.0473	7	0.0609	7
System and Mechanism for Quality Assurance (I)	0.0369	8	0.0340	8	0.0457	8
Preservation of Arts and Culture (F)	0.0234	9	0.0220	9	0.0273	9

Table 10 The sensitivity analysis of sub-criteria weight ranking by extending/stretching the Triangular membership function up/down by the number 0.5.

Alternative	TFN		Stretch		Extend	
	Weight	Rank	Weight	Rank	Weight	Rank
W1 (Teacher quality)	0.2727	1	0.2536	1	0.2335	1
W2 (Administrative)	0.2475	2	0.2474	2	0.2157	2
W3 (Research)	0.1512	3	0.1434	3	0.1455	3
W4 (Teaching Learning Process)	0.1368	4	0.1337	4	0.1591	4
W5 (Academic Service)	0.1087	5	0.1200	5	0.1235	5
W6 (Student)	0.0981	6	0.1020	6	0.1227	6

Table 11 The comparison of main criteria weight ranking between FAHP and AHP.

Main criteria	FAHP		AHP	
	Weight	Rank	Weight	Rank
Graduate Production (B)	0.3226	1	0.3084	1
Research (D)	0.3202	2	0.3060	2
Academic Services to the Community (E)	0.0970	3	0.0914	3
Philosophy, Commitments, Objectives, and Implementation Plans (A)	0.0816	4	0.0761	4
Administration and Management (G)	0.0714	5	0.0664	5
Finance and Budgeting (H)	0.0549	6	0.0507	6
Student Development Activities (C)	0.0509	7	0.0463	7
System and Mechanism for Quality Assurance (I)	0.0369	8	0.0332	8
Preservation of Arts and Culture (F)	0.0234	9	0.0216	9

Table 12 The comparison of alternative weight ranking between FAHP and AHP.

Alternative	FAHP		AHP	
	Weight	Rank	Weight	Rank
W1 (Teacher quality)	0.2727	1	0.2744	1
W2 (Administrative)	0.2475	2	0.2454	2
W3 (Research)	0.1512	3	0.1493	3
W4 (Teaching Learning Process)	0.1368	4	0.1341	4
W5 (Academic Service)	0.1087	5	0.1061	5
W6 (Student)	0.0981	6	0.0909	6