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Improving and Boosting Higher Education Competitiveness: Assessment, Ranking, and Analysis using TreeSoft Set

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Abstract: Higher education competitiveness has become a crucial factor in determining the global standing of universities and colleges. With rapid advancements in technology, globalization, and the evolving job market, institutions must continuously adapt to enhance their academic offerings, research output, and industry collaborations. This paper explores the key factors influencing higher education competitiveness, including academic excellence, infrastructure, internationalization, financial stability, industry partnerships, and student satisfaction. By employing a multi-criteria decision-making (MCDM) approach, this study evaluates and ranks higher education institutions based on these essential criteria. Two MCDM methods are used in this study such as CIMAS methodology to compute the criteria weights and the WASPAS methodology to rank the alternatives. We used the TreeSoft set to deal with different criteria and sub-criteria by dividing the criteria and sub-criteria into a Tree to obtain the relations.

Keywords: TreeSoft Set; Higher Education Competitiveness; Assessment; Analysis; Ranking.

1. Introduction

Higher education institutions play a pivotal role in shaping knowledge economies and driving societal progress. The growing demand for quality education, coupled with the rapid integration of digital technologies, has intensified competition among universities worldwide. As students, employers, and policymakers seek institutions that offer exceptional academic programs, robust research opportunities, and strong industry links, the ability to remain competitive has become a critical challenge[1], [2]. Universities must continuously evolve to meet these expectations while maintaining high standards of education, research, and employability outcomes. One of the fundamental aspects of higher education competitiveness is academic excellence, which encompasses faculty qualifications, curriculum innovation, and research contributions. Institutions with distinguished faculty members and cutting-edge research facilities tend to attract top students and funding opportunities. Moreover, the quality of education is heavily influenced by an institution's ability to integrate interdisciplinary learning, real-world applications, and digital advancements into its academic framework. Universities that foster a dynamic learning environment gain a strategic advantage in the global education sector[3], [4]. Beyond academic performance, infrastructure and technological resources significantly impact an institution's competitiveness. State-of-the-art laboratories, digital learning platforms, and well-equipped libraries enhance students' learning experiences and facilitate groundbreaking research. Additionally, the implementation of smart campus initiatives and IT-enabled classrooms contributes to a more engaging and interactive educational environment. As universities embrace digital transformation, those with superior technological integration stand out in the highly competitive higher education landscape[5], [6].

Industry collaboration and employability outcomes are also key indicators of institutional competitiveness. Universities that establish strong partnerships with industries, provide extensive internship programs, and incorporate skill-based training in their curricula produce graduates who are better prepared for the workforce. The growing emphasis on entrepreneurship, innovation hubs, and startup ecosystems within academic institutions further enhances their reputation and attractiveness to prospective students and employers[7], [8].

Furthermore, internationalization and global engagement have become essential components of higher education competitiveness. Universities that foster student exchange programs, research collaborations, and international faculty recruitment create a diverse and globally connected academic community. Institutions that establish strong networks with international organizations and maintain high global rankings gain a competitive edge by attracting students from different cultural and academic backgrounds[9], [10].

As the higher education sector continues to evolve, institutions must adopt data-driven decision-making processes to assess and enhance their competitive position. Multi-criteria decision-making (MCDM) methodologies provide an effective framework for evaluating universities based on various performance metrics. By analyzing factors such as academic excellence, infrastructure, financial sustainability, and global outreach, MCDM approaches enable a systematic assessment of higher education competitiveness. This study applies such methodologies to rank institutions and identify areas for strategic improvement, ultimately contributing to the advancement of higher education standards worldwide.

This study proposes MCDM methods to compute the criteria weights by the CIMAS methodology and ranking the alternatives by the WASPAS methodology. We use the TreeSoft set to deal with criteria and sub-criteria to divide it into a Tree. We compute the criteria weights in each criterion and in the main criteria.

2. Methodological framework

The methodological framework of this study is built to compute the criteria weights and ranking of the alternatives of MCDM problem. Three main steps of this study are to evaluate the MCDM problem. In the first step, we use the TreeSoft set to deal with the different criteria and alternatives. in the second step, we apply the CIMAS method to compute the criteria weights. In the third step, we apply the WASPAS method to rank the alternatives.

Dividing the criteria and sub-criteria into a Tree

The TreeSoft set is a hierarchical soft set with multi-level criteria presented in Tree to show the relations between criteria and sub criteria[11], [12].

Let U be a universe discourse and H non-empty subset of U and the powerset of U is P(H). Let the set of criteria $D = \{D_1, D_2, \dots D_n\}; n \geq 1$. These criteria can be divided into sub-criteria such as:

$$D_1 = \{D_{1-1}, D_{1-2} \ , D_{1-3}, \dots\} \tag{1}$$

$$D_2 = \{D_{2-1}, D_{2-2} \ , D_{2-3}, \dots\} \tag{2}$$

$$D_3 = \{D_{3-1}, D_{3-2} \ , D_{3-3}, \dots\} \tag{3}$$

$$D_4 = \{D_{4-1}, D_{4-2} \ , D_{4-3}, \dots\} \tag{4}$$

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$$D_n = \{D_{n-1}, D_{n-2} \ , D_{n-3}, \dots\} \tag{5}$$

A TreeSoft set is a mapping defined as:

$$F: P(Tree(D)) \rightarrow P(H) \tag{6}$$

Tree(A) presents a set of nodes from level 1 to level m.

Calculating the criteria weights

We can compute the criteria weights by the CIMAS methodology[13], [14].

Create the decision matrix.

Experts create the decision matrix between the criteria and alternatives.

Normalize the decision matrix

The decision matrix is normalized such as:

$$y_{ij} = \frac{x_{ij}}{r_j}; i = 1, \dots m; j = 1, \dots, n \tag{7}$$

Where r_j refers to the standard deviation.

Computation of the weighted decision matrix

$$h_{ij} = y_{ij} v_{ij} \tag{8}$$

Where v_{ij} refers to the weight of experts.

Compute the maximum and minimum values in the weighted decision matrix.

$$h_{ij}^{max} = \max_i h_{ij} \tag{9}$$

$$h_{ij}^{min} = \min_i h_{ij} \tag{10}$$

Compute the difference between the maximum and minimum values.

$$l_j = h_{ij}^{max} - h_{ij}^{min} \tag{11}$$

Compute the criteria weights.

$$w_j = \frac{l_j}{\sum_{j=1}^{n} l_j} \tag{12}$$

Ranking the alternatives

This step is applied to rank the alternatives by the WASPAS method[15], [16].

Normalize the decision matrix for the beneficial and non-beneficial criteria

$$u_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \tag{13}$$

$$u_{ij} = \frac{x_{ij}}{\min_i x_{ij}} \tag{14}$$

Compute the additive relative importance

$$D_i^{(1)} = \sum_{j=1}^{n} u_{ij} w_j \tag{15}$$

Compute the multiplicative relative importance

$$D_i^{(2)} = \prod_{j=1}^{n} \left(u_{ij}\right)^{w_j} \tag{16}$$

Compute the joint generalized criterion

$$D_i = \frac{1}{2}\left(D_i^{(1)} + D_i^{(2)}\right) \tag{17}$$

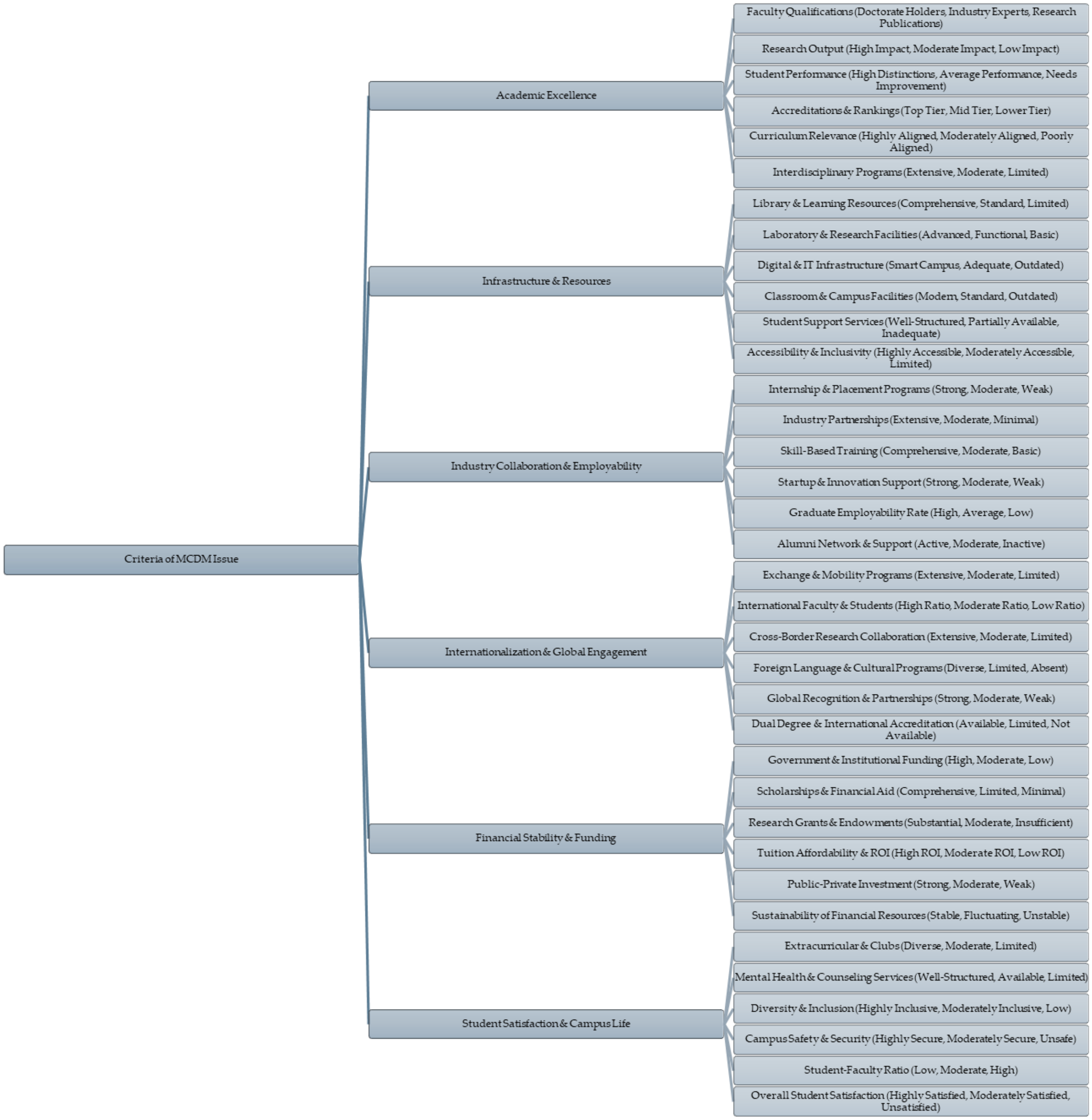

Fig 1. The criteria of Higher Education Competitiveness.

3. Case Study

This section shows the case study of the Higher Education Competitiveness Evaluation. We collect six criteria and eleven universities to be evaluated. Three experts evaluated these criteria and eleven universities. We used the TreeSoft set to divide the criteria into different levels. We divided it into two levels. In the first level, we put the six main criteria. In the second level, we put the sub-criteria. Then we put the values of each sub-criteria to select the best one.

Calculating the criteria weights

In this part, we apply the steps of the CIMAS methodology to calculate the criteria weights. This step is divided into different stages. First, we compute the criteria weights of the main criteria, then we compute the weights in each sub-criterion. We have six main criteria and each criterion has six sub-criteria.

Create the decision matrix.

We create the decision matrix using a scale between 0.1 to 0.9 to evaluate the criteria and alternatives by the experts and decision makers.

Eq. (7) is used to normalize the decision matrix as shown in Table 1.

Then we obtain the weighted decision matrix using Eq. (2) as shown in Table 2.

Then we compute the maximum and minimum values in the weighted decision matrix using Eqs. (9 and 10).

Then we compute the difference between the maximum and minimum values using Eq. (11).

Then we compute the criteria weights using Eq. (12) as shown in Fig 2.

Table 1. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	1.969431	3.190429	4.296314	2.724285	3.988006	1.692277
A_2	4.647021	5.774561	1.569217	3.16582	3.208086	4.633238
A_3	3.131694	4.020019	2.25007	3.991653	2.560925	2.724461
A_4	2.839604	5.541966	2.003268	1.792156	4.669888	1.032183
A_5	4.549464	2.554928	4.388404	1.792156	3.828696	3.631511
A_6	4.418807	3.302075	2.023119	4.819717	3.373816	3.016659
A_7	3.968768	3.416305	3.796571	1.899938	3.144479	3.113984
A_8	3.357295	3.391237	2.003268	3.360571	4.703151	2.061056
A_9	4.777678	4.252614	2.162277	2.425468	1.979122	3.532199
A_{10}	3.809948	4.680589	3.116332	3.993883	5.28437	2.257694
A_{11}	2.100088	3.935509	3.024241	3.16582	4.440552	2.477725

Table 2. The weighted decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.309207	0.626616	0.740883	0.419662	0.648435	0.266541
A_2	0.729597	1.134153	0.270605	0.487678	0.521623	0.729755
A_3	0.491686	0.789552	0.388016	0.614894	0.416397	0.429114
A_4	0.445827	1.08847	0.345456	0.276072	0.759307	0.162573
A_5	0.714281	0.501801	0.756764	0.276072	0.622532	0.571979

A_6	0.693767	0.648544	0.348879	0.742452	0.54857	0.475137
A_7	0.623109	0.670979	0.654704	0.292676	0.511281	0.490466
A_8	0.527106	0.666056	0.345456	0.517679	0.764715	0.324625
A_9	0.750111	0.835235	0.372877	0.373631	0.321798	0.556337
A_{10}	0.598174	0.919291	0.5374	0.615237	0.859219	0.355597
A_{11}	0.329721	0.772954	0.521519	0.487678	0.722017	0.390253

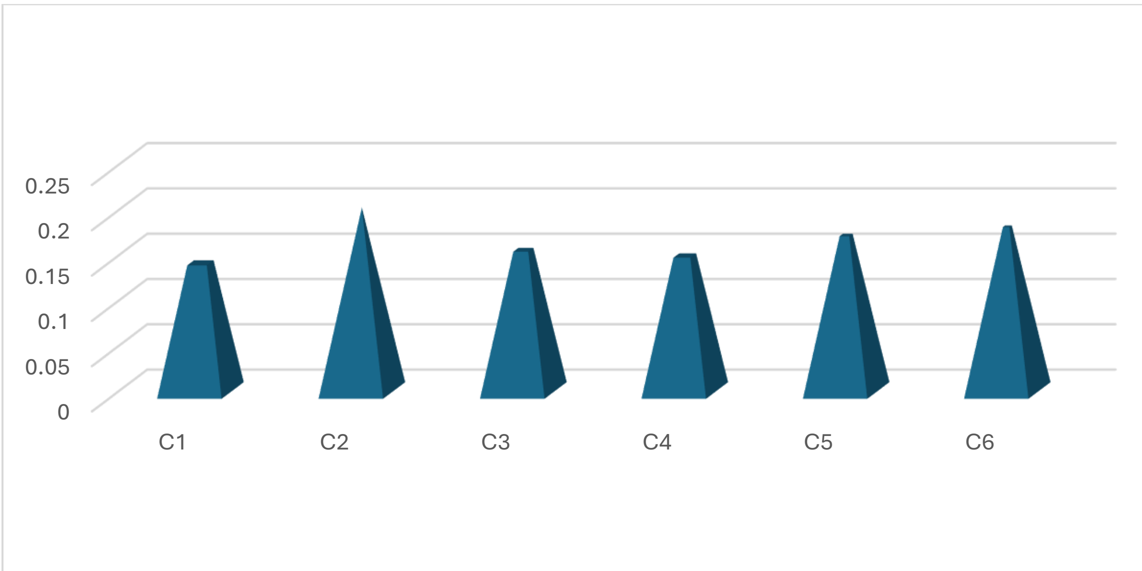

Fig 2. The weights of the main criteria.

Then we apply the previous steps in each sub-criteria to compute the weights of each sub-criterion.

In the First sub-criterion

Fig 3 shows the normalized decision matrix. Fig 4 shows the weighted decision matrix. Fig 5 shows the weights of first sub-criterion.

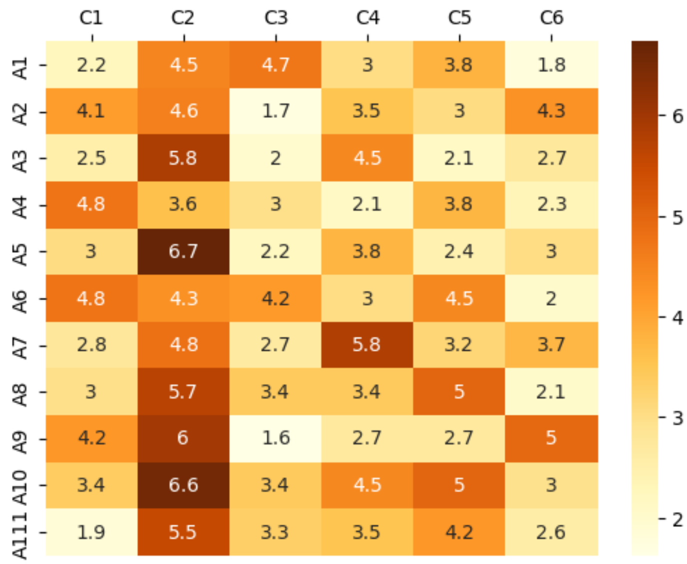

Fig 3. Normalized values.

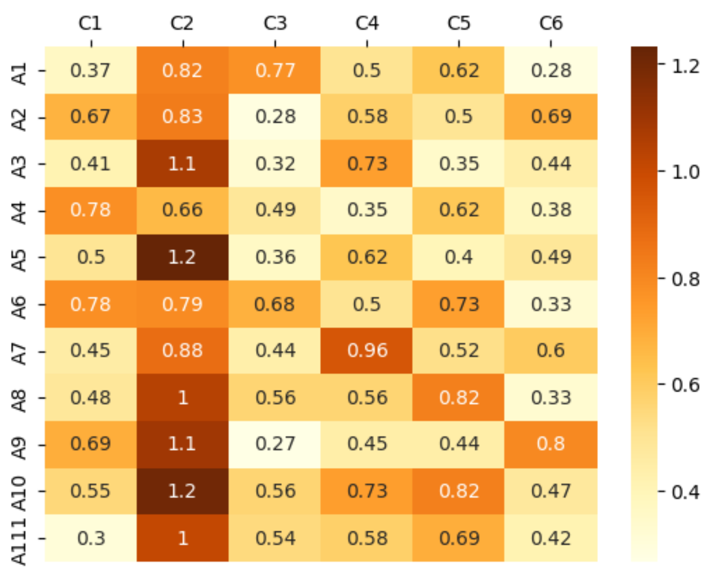

Fig 4. Weighted decision values.

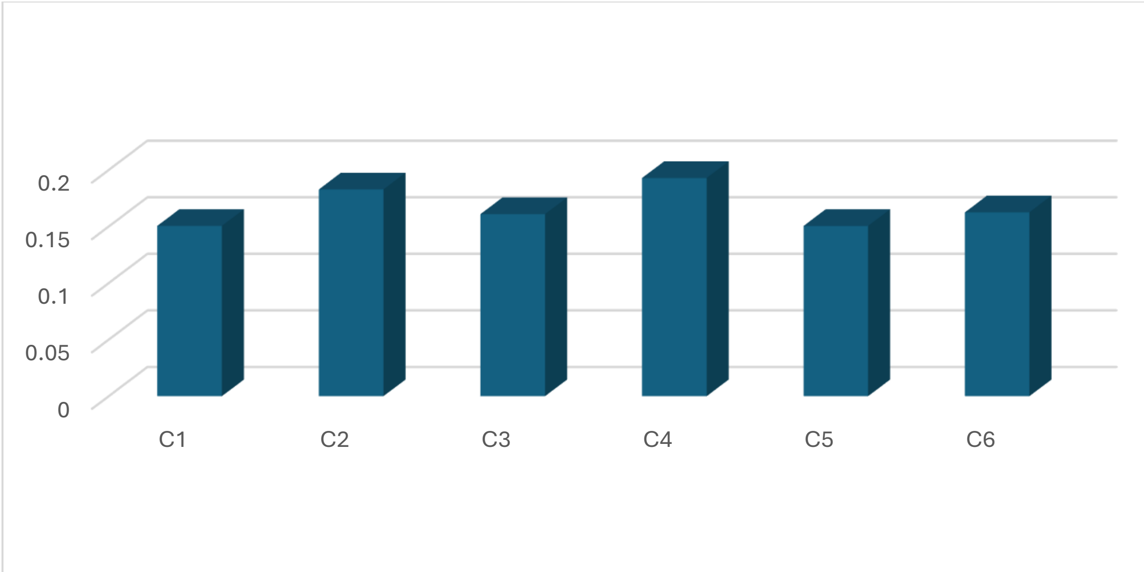

Fig 5. Weights of first sub-criterion.

In the second sub-criterion

Fig 6 shows the normalized decision matrix. Fig 7 shows the weighted decision matrix. Fig 8 shows the weights of first sub-criterion.

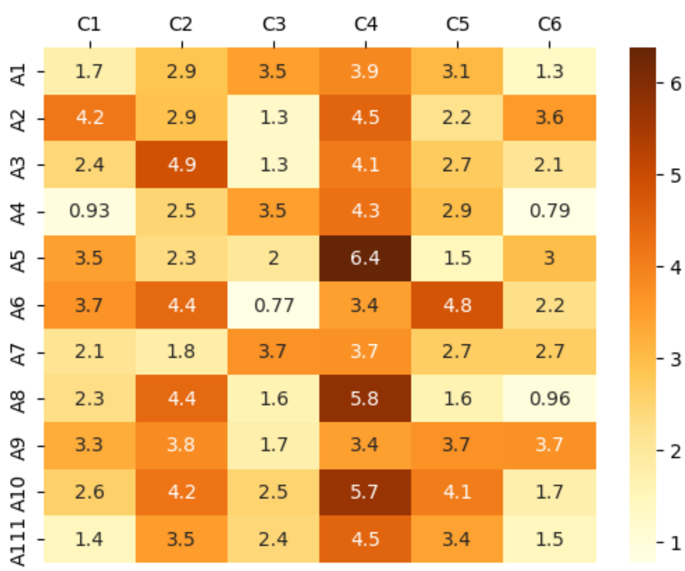

Fig 6. Normalized values.

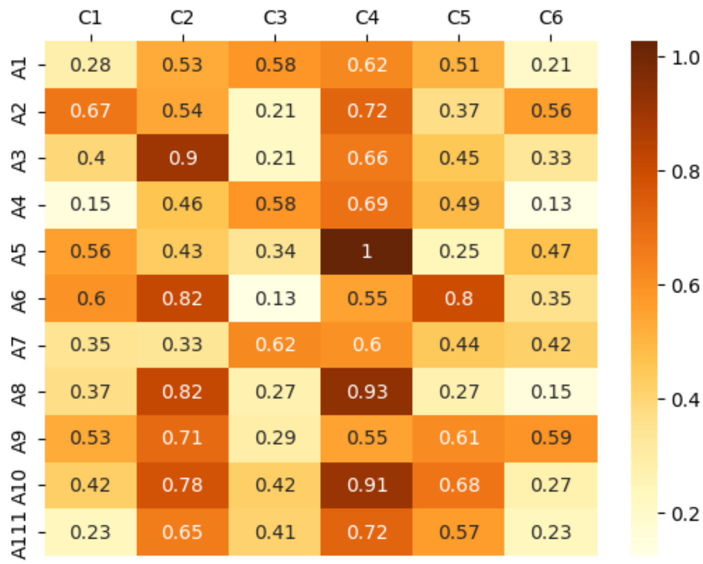

Fig 7. Weighted decision values.

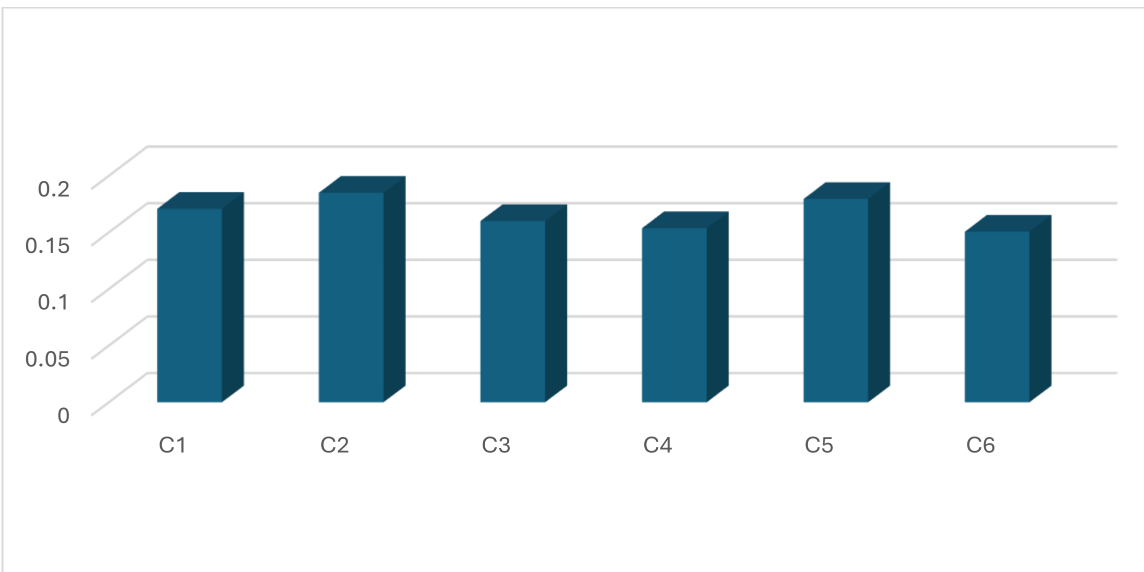

Fig 8. Weights of second sub-criterion.

In the third sub-criterion

Fig 9 shows the normalized decision matrix. Fig 10 shows the weighted decision matrix. Fig 11 shows the weights of the third sub-criterion.

Fig 9. Normalized values.

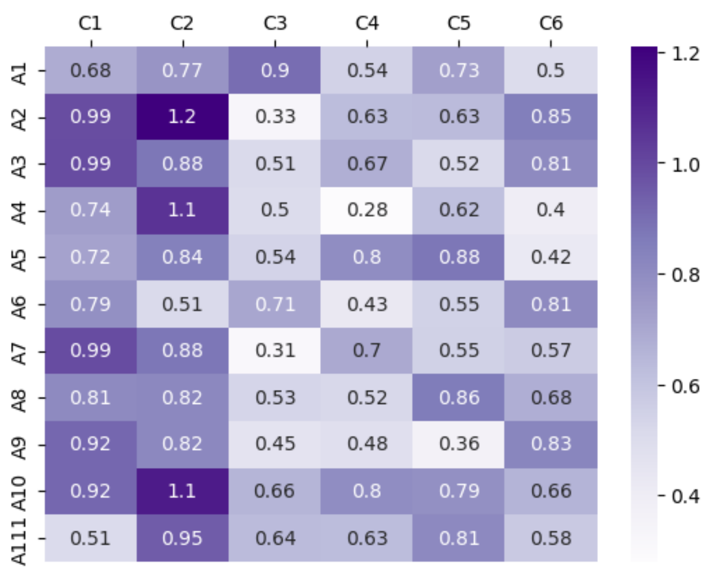

Fig 10. Weighted decision values.

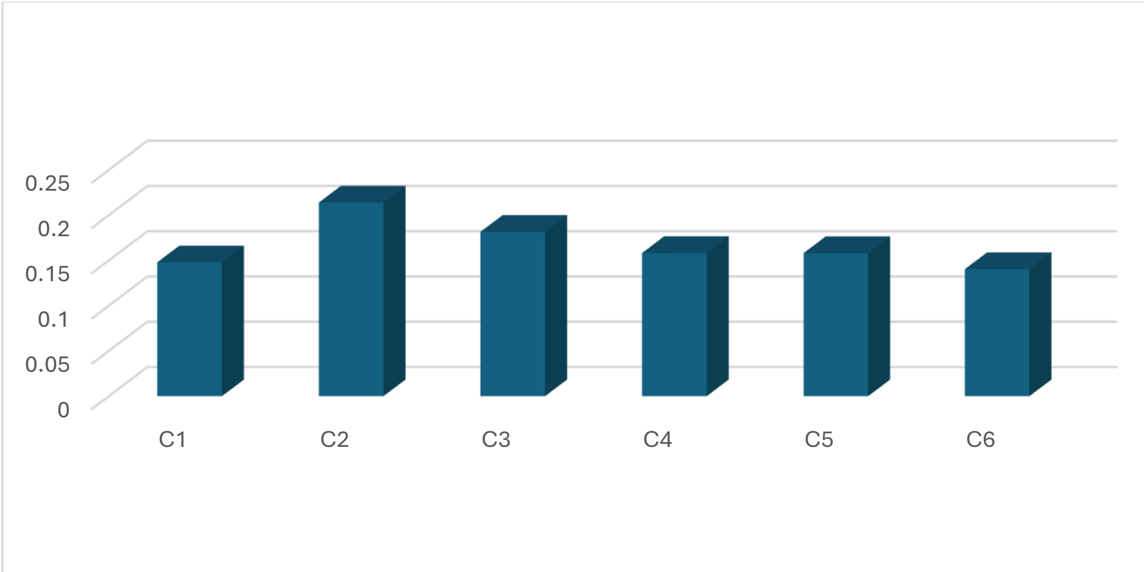

Fig 11. Weights of third sub-criterion.

In the fourth sub-criterion

Fig 12 shows the normalized decision matrix. Fig 13 shows the weighted decision matrix. Fig 14 shows the weights of the fourth criterion.

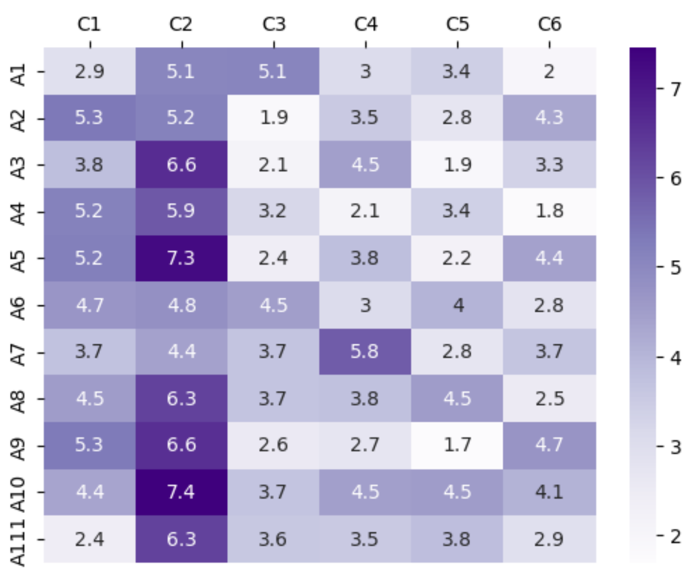

Fig 12. Normalized values.

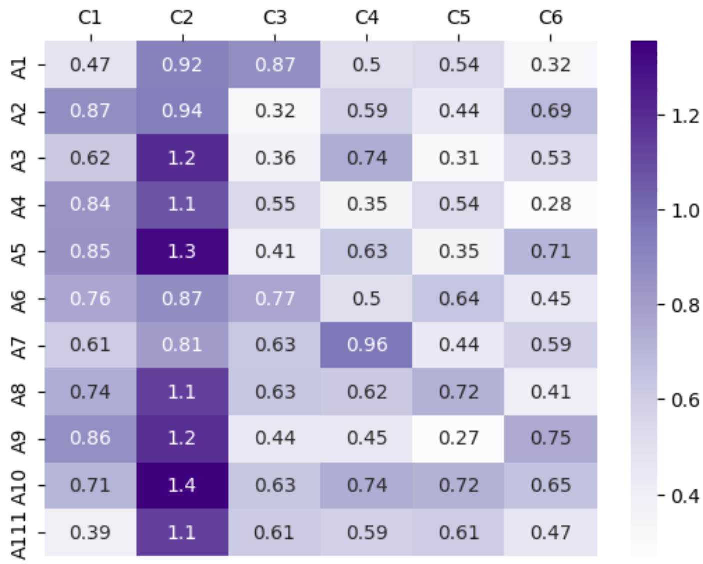

Fig 13. Weighted decision values.

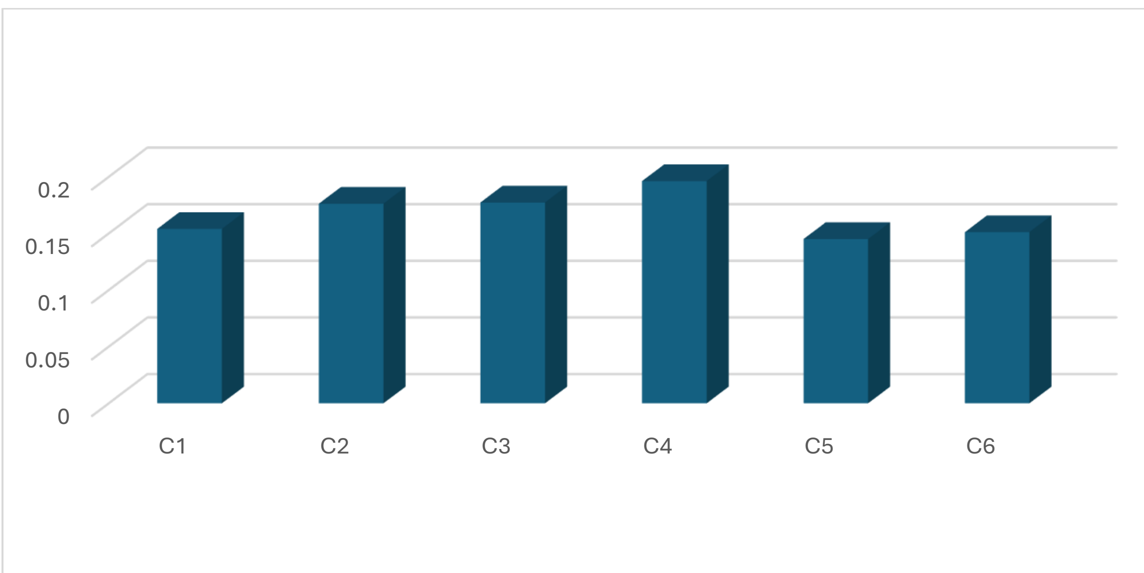

Fig 14. Weights of fourth sub-criterion.

In the fifth sub-criterion

Fig 15 shows the normalized decision matrix. Fig 16 shows the weighted decision matrix. Fig 17 shows the weights of fifth sub-criterion.

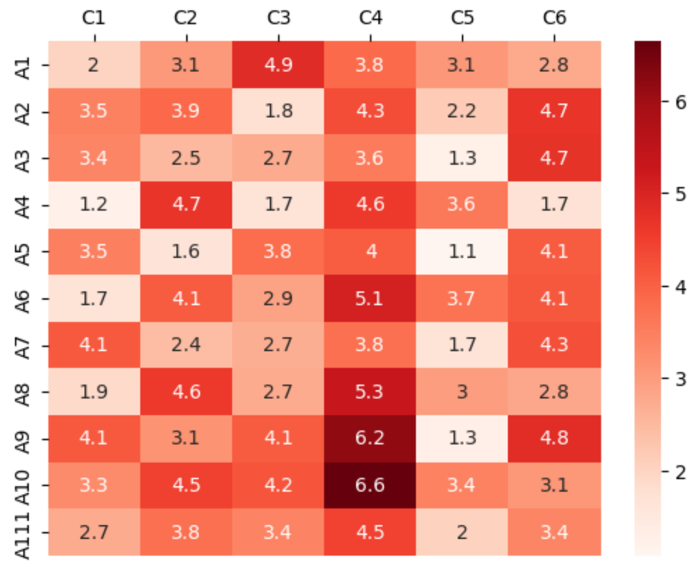

Fig 15. Normalized values.

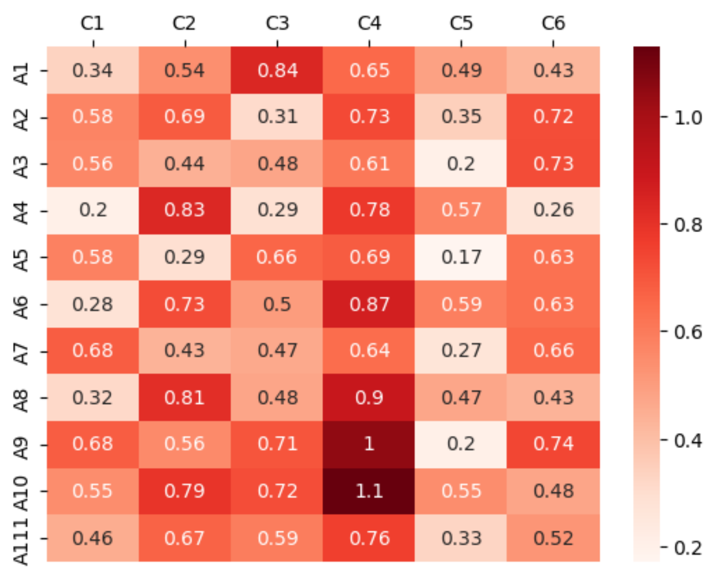

Fig 16. Weighted decision values.

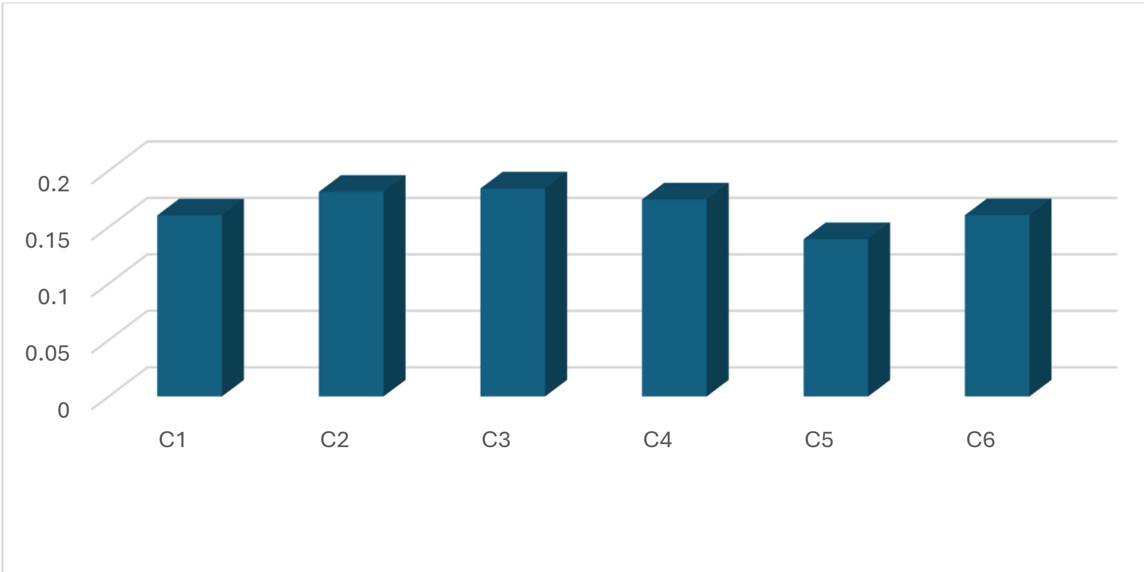

Fig 17. Weights of fifth sub-criterion.

In the sixth sub-criterion

Fig 18 shows the normalized decision matrix. Fig 19 shows the weighted decision matrix. Fig 20 shows the weights of sixth sub-criterion.

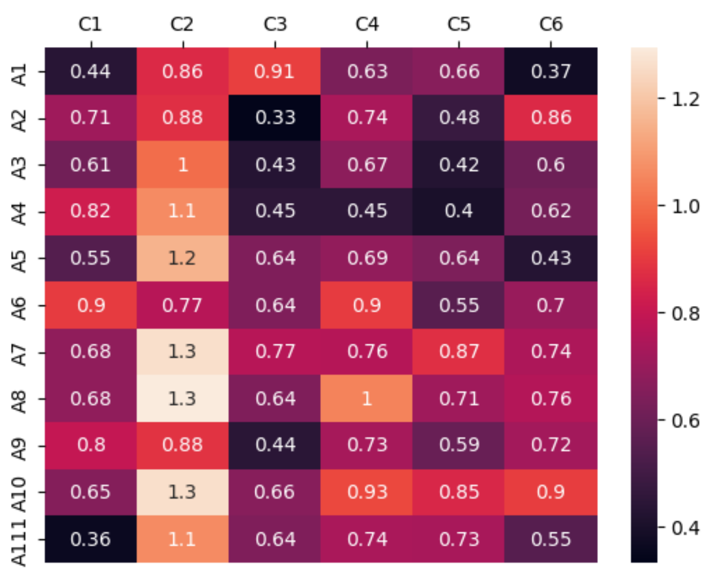

Fig 18. Normalized values.

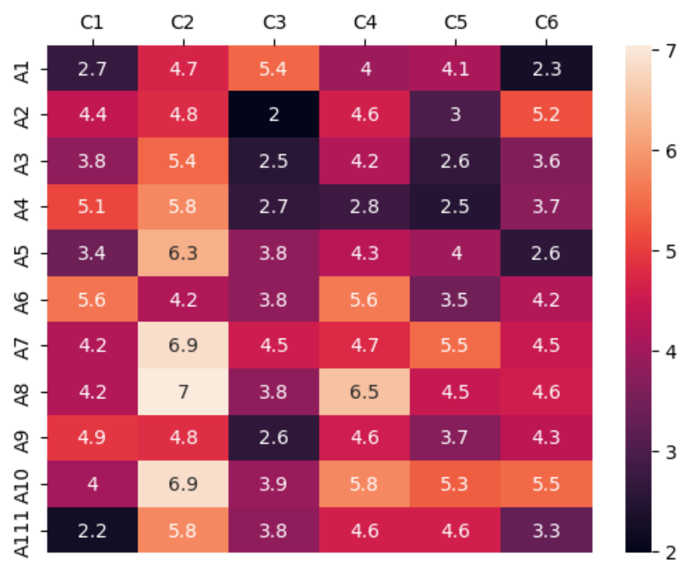

Fig 19. Weighted decision values.

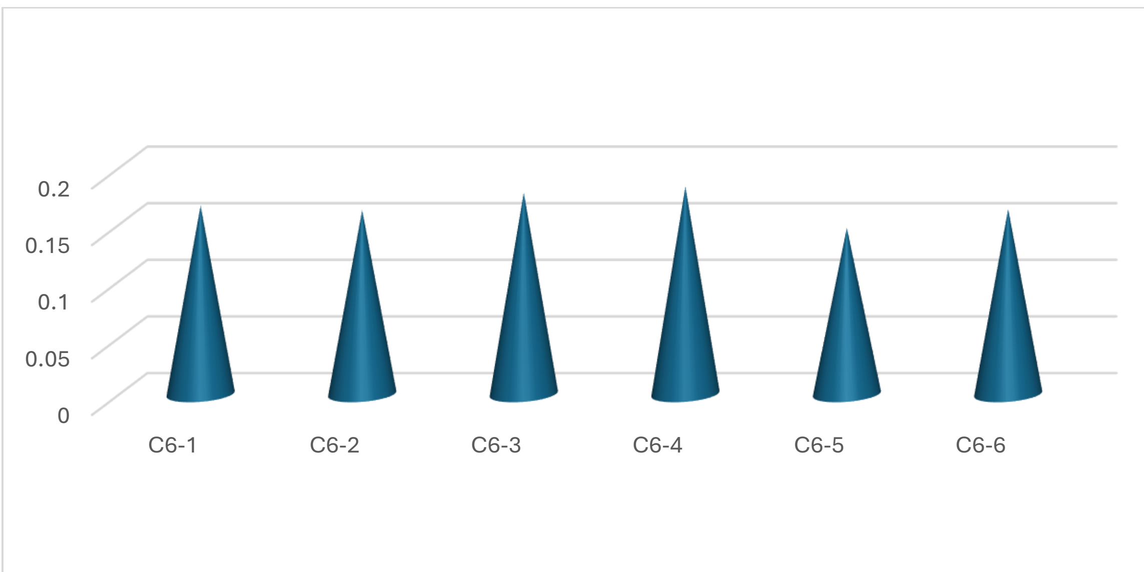

Fig 20. Weights of sixth sub-criterion.

Then we compute the global weights of the criteria by multiplications the weights of sub criteria by the weights of the main criteria. Then we select the best values of each sub-criterion.

Ranking the alternatives

Then we apply the steps of the WASPAS method to rank the alternatives.

Eq. (13) is used to normalize the decision matrix for the beneficial and non-beneficial criteria as shown in Table 3.

Eq. (15) is used to compute the additive relative importance as shown in Table 4.

Eq. (16) is used to compute the multiplicative relative importance as shown in Table 5.

Eq. (17) is used to compute the joint generalized criterion. Then we rank the alternatives as shown in Fig 21.

Table 3. Normalizations by the WASPAS method.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}
C_{1-1}	0.412215	0.972653	0.655485	0.594348	0.952233	0.924886	0.83069	0.702704	1	0.797448	0.439562
C_{1-2}	0.552497	1	0.69616	0.959721	0.442445	0.571831	0.591613	0.587272	0.736439	0.810553	0.681525
C_{1-3}	0.979015	0.357583	0.512731	0.456491	1	0.461015	0.865137	0.456491	0.492725	0.710129	0.689144
C_{1-4}	0.565238	0.656848	0.828192	0.371838	0.371838	1	0.394201	0.697255	0.503239	0.828655	0.656848
C_{1-5}	0.754679	0.60709	0.484623	0.883717	0.724532	0.638452	0.595053	0.890012	0.374524	1	0.840318
C_{1-6}	0.365247	1	0.588025	0.222778	0.783795	0.651091	0.672097	0.444841	0.762361	0.487282	0.534772
C_{2-1}	0.473103	0.86837	0.532881	1	0.641171	1	0.581393	0.623275	0.886966	0.707309	0.389877
C_{2-2}	0.665427	0.677016	0.86837	0.532881	1	0.641171	0.712538	0.845084	0.886966	0.976229	0.820828
C_{2-3}	1	0.365247	0.418072	0.630037	0.470896	0.883681	0.56659	0.72535	0.344527	0.72535	0.703915
C_{2-4}	0.523721	0.608602	0.767362	0.365247	0.651043	0.523721	1	0.588025	0.466276	0.767791	0.608602
C_{2-5}	0.754679	0.60709	0.423389	0.748882	0.484623	0.889515	0.631936	1	0.5405	1	0.840318
C_{2-6}	0.357583	0.865137	0.554701	0.47174	0.611919	0.409299	0.751259	0.414522	1	0.596251	0.52355
C_{3-1}	0.418072	1	0.588025	0.222778	0.831285	0.883681	0.513766	0.550776	0.783795	0.625036	0.344527
C_{3-2}	0.588025	0.598266	1	0.513766	0.481852	0.905544	0.370582	0.905544	0.783795	0.862675	0.72535
C_{3-3}	0.939581	0.343179	0.343179	0.939581	0.552497	0.209318	1	0.438104	0.472879	0.681525	0.661386
C_{3-4}	0.60709	0.705483	0.644249	0.668654	1	0.5405	0.583402	0.908564	0.5405	0.890012	0.705483
C_{3-5}	0.637381	0.461015	0.564727	0.611919	0.311089	1	0.554701	0.337297	0.767348	0.844572	0.709709
C_{3-6}	0.350233	0.958893	0.563853	0.21362	0.797113	0.603773	0.715676	0.259158	1	0.467251	0.396045
C_{4-1}	0.692684	0.999363	1	0.748353	0.724556	0.79517	1	0.818967	0.929386	0.929386	0.512288
C_{4-2}	0.634639	1	0.725375	0.874049	0.697255	0.423093	0.725838	0.674584	0.674584	0.931061	0.78285
C_{4-3}	1	0.365247	0.566162	0.555778	0.598266	0.783795	0.344527	0.588025	0.503287	0.72535	0.703915
C_{4-4}	0.682114	0.792667	0.847943	0.352007	1	0.537937	0.875923	0.6555	0.607296	1	0.792667
C_{4-5}	0.830629	0.722334	0.587542	0.702704	1	0.621696	0.628137	0.979581	0.412215	0.898086	0.924886
C_{4-6}	0.584099	1	0.947197	0.46363	0.497221	0.946653	0.671399	0.792774	0.966953	0.772475	0.678287
C_{5-1}	0.544817	1	0.710428	0.965549	0.972626	0.875854	0.696896	0.848479	0.993482	0.814525	0.448976
C_{5-2}	0.68163	0.693501	0.889515	0.791121	0.975153	0.644249	0.595053	0.840815	0.883717	1	0.840815
C_{5-3}	1	0.365247	0.418072	0.630037	0.470896	0.883681	0.724921	0.72535	0.503287	0.72535	0.703915
C_{5-4}	0.523721	0.608602	0.767362	0.365247	0.651043	0.523721	1	0.646042	0.466276	0.767791	0.608602
C_{5-5}	0.754679	0.60709	0.423389	0.748882	0.484623	0.889515	0.60709	1	0.374524	1	0.840318
C_{5-6}	0.423389	0.91392	0.70598	0.374524	0.938766	0.595053	0.779085	0.540003	1	0.865165	0.6199
C_{6-1}	0.491475	0.84228	0.825071	0.2986	0.848279	0.409431	1	0.461899	1	0.801389	0.666877
C_{6-2}	0.649361	0.82468	0.532113	1	0.350902	0.871075	0.520015	0.975856	0.666561	0.952659	0.80101
C_{6-3}	1	0.365247	0.56659	0.344527	0.783795	0.598266	0.555778	0.566162	0.84124	0.862675	0.703915
C_{6-4}	0.578623	0.649195	0.538364	0.690559	0.608515	0.766235	0.567151	0.800916	0.929428	1	0.672403
C_{6-5}	0.828192	0.588371	0.342947	0.977329	0.291692	1	0.451213	0.805521	0.348705	0.931061	0.55403
C_{6-6}	0.576507	0.971884	0.979569	0.354514	0.847423	0.854046	0.8816	0.583505	1	0.639175	0.701468

Table 4. Values of additive relative importance.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}
C_{1-1}	0.008738	0.020619	0.013895	0.012599	0.020186	0.019606	0.017609	0.014896	0.021198	0.016905	0.009318
C_{1-2}	0.014221	0.02574	0.017919	0.024703	0.011389	0.014719	0.015228	0.015116	0.018956	0.020864	0.017542
C_{1-3}	0.022191	0.008105	0.011622	0.010347	0.022667	0.01045	0.01961	0.010347	0.011169	0.016097	0.015621
C_{1-4}	0.015351	0.01784	0.022493	0.010099	0.010099	0.027159	0.010706	0.018937	0.013668	0.022506	0.01784
C_{1-5}	0.015995	0.012867	0.010271	0.01873	0.015356	0.013532	0.012612	0.018863	0.007938	0.021194	0.01781
C_{1-6}	0.008359	0.022887	0.013458	0.005099	0.017939	0.014901	0.015382	0.010181	0.017448	0.011152	0.012239
C_{2-1}	0.016331	0.029976	0.018395	0.034519	0.022133	0.034519	0.020069	0.021515	0.030617	0.024416	0.013458
C_{2-2}	0.024871	0.025304	0.032456	0.019917	0.037376	0.023964	0.026632	0.031586	0.033151	0.036487	0.030679
C_{2-3}	0.032328	0.011808	0.013515	0.020368	0.015223	0.028567	0.018317	0.023449	0.011138	0.023449	0.022756
C_{2-4}	0.01627	0.018907	0.023839	0.011347	0.020225	0.01627	0.031066	0.018268	0.014485	0.023852	0.018907
C_{2-5}	0.027376	0.022022	0.015359	0.027166	0.01758	0.032267	0.022924	0.036275	0.019607	0.036275	0.030483
C_{2-6}	0.010885	0.026334	0.016885	0.01436	0.018627	0.012459	0.022868	0.012618	0.03044	0.01815	0.015937
C_{3-1}	0.0096	0.022962	0.013502	0.005115	0.019088	0.020291	0.011797	0.012647	0.017997	0.014352	0.007911

C_{3-2}	0.019538	0.019879	0.033227	0.017071	0.01601	0.030088	0.012313	0.030088	0.026043	0.028664	0.024101
C_{3-3}	0.026493	0.009677	0.009677	0.026493	0.015579	0.005902	0.028197	0.012353	0.013334	0.019217	0.018649
C_{3-4}	0.014913	0.01733	0.015826	0.016426	0.024565	0.013278	0.014331	0.022319	0.013278	0.021863	0.01733
C_{3-5}	0.015648	0.011318	0.013864	0.015023	0.007637	0.02455	0.013618	0.008281	0.018839	0.020735	0.017424
C_{3-6}	0.007635	0.020905	0.012293	0.004657	0.017378	0.013163	0.015602	0.00565	0.021801	0.010187	0.008634
C_{4-1}	0.015892	0.022928	0.022943	0.017169	0.016623	0.018244	0.022943	0.01879	0.021323	0.021323	0.011753
C_{4-2}	0.016666	0.02626	0.019048	0.022953	0.01831	0.01111	0.01906	0.017715	0.017715	0.02445	0.020558
C_{4-3}	0.02642	0.00965	0.014958	0.014684	0.015806	0.020708	0.009102	0.015535	0.013297	0.019164	0.018597
C_{4-4}	0.019941	0.023172	0.024788	0.01029	0.029233	0.015726	0.025606	0.019163	0.017753	0.029233	0.023172
C_{4-5}	0.01795	0.01561	0.012697	0.015186	0.02161	0.013435	0.013574	0.021169	0.008908	0.019408	0.019987
C_{4-6}	0.013153	0.022518	0.021329	0.01044	0.011196	0.021316	0.015118	0.017851	0.021774	0.017394	0.015273
C_{5-1}	0.014998	0.027529	0.019557	0.026581	0.026775	0.024111	0.019185	0.023358	0.02735	0.022423	0.01236
C_{5-2}	0.021202	0.021571	0.027668	0.024608	0.030332	0.020039	0.018509	0.026154	0.027488	0.031105	0.026154
C_{5-3}	0.031615	0.011547	0.013218	0.019919	0.014888	0.027938	0.022919	0.022932	0.015912	0.022932	0.022255
C_{5-4}	0.015687	0.018229	0.022985	0.01094	0.019501	0.015687	0.029953	0.019351	0.013966	0.022998	0.018229
C_{5-5}	0.018045	0.014516	0.010124	0.017906	0.011588	0.021269	0.014516	0.023911	0.008955	0.023911	0.020093
C_{5-6}	0.011671	0.025192	0.01946	0.010324	0.025877	0.016403	0.021476	0.014885	0.027565	0.023848	0.017088
C_{6-1}	0.014819	0.025397	0.024878	0.009003	0.025577	0.012345	0.030152	0.013927	0.030152	0.024164	0.020108
C_{6-2}	0.019106	0.024264	0.015656	0.029422	0.010324	0.025629	0.0153	0.028712	0.019612	0.028029	0.023568
C_{6-3}	0.032229	0.011771	0.01826	0.011104	0.025261	0.019281	0.017912	0.018247	0.027112	0.027803	0.022686
C_{6-4}	0.019205	0.021548	0.017869	0.022921	0.020197	0.025432	0.018825	0.026584	0.030849	0.033191	0.022318
C_{6-5}	0.022017	0.015641	0.009117	0.025982	0.007754	0.026584	0.011995	0.021414	0.00927	0.024752	0.014728
C_{6-6}	0.017068	0.028774	0.029002	0.010496	0.025089	0.025285	0.026101	0.017276	0.029607	0.018924	0.020768

Table 5. Values of multiplicative relative importance.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}
C_{1-1}	0.981389	0.999412	0.991086	0.989031	0.998963	0.998346	0.996075	0.992549	1	0.995213	0.982726
C_{1-2}	0.984844	1	0.990721	0.998942	0.979229	0.985717	0.98658	0.986393	0.992156	0.994608	0.990179
C_{1-3}	0.999519	0.976959	0.984972	0.982382	1	0.982601	0.996722	0.982382	0.984084	0.992271	0.991596
C_{1-4}	0.984625	0.98865	0.994893	0.973489	0.973489	1	0.975035	0.990254	0.981523	0.994908	0.98865
C_{1-5}	0.994052	0.989478	0.984764	0.997383	0.993194	0.990535	0.989058	0.997533	0.9794	1	0.996319
C_{1-6}	0.977212	1	0.987921	0.966217	0.99444	0.990227	0.990947	0.981632	0.993809	0.983681	0.985777
C_{2-1}	0.974495	0.99514	0.978506	1	0.984775	1	0.981453	0.983813	0.995868	0.988118	0.968008
C_{2-2}	0.984891	0.985527	0.994739	0.976748	1	0.983525	0.987412	0.993729	0.995527	0.999101	0.992648
C_{2-3}	1	0.967964	0.972201	0.985176	0.975947	0.99601	0.981802	0.989673	0.966139	0.989673	0.988714
C_{2-4}	0.980107	0.984691	0.991808	0.969195	0.986756	0.980107	1	0.98364	0.976576	0.991825	0.984691
C_{2-5}	0.989842	0.982059	0.969304	0.989565	0.974065	0.995762	0.983489	1	0.977929	1	0.993709
C_{2-6}	0.969181	0.9956	0.982221	0.977389	0.985161	0.973174	0.991332	0.97355	1	0.984383	0.980495
C_{3-1}	0.980174	1	0.987882	0.966109	0.995766	0.997165	0.984824	0.986398	0.994422	0.989267	0.975829
C_{3-2}	0.982512	0.983076	1	0.978114	0.976032	0.996709	0.967554	0.996709	0.991938	0.995104	0.989388
C_{3-3}	0.998244	0.970293	0.970293	0.998244	0.98341	0.956861	1	0.976998	0.979104	0.989247	0.988411
C_{3-4}	0.987815	0.991466	0.989257	0.990161	1	0.985	0.986849	0.997647	0.985	0.997142	0.991466
C_{3-5}	0.989004	0.98117	0.98607	0.988014	0.97174	1	0.985636	0.973672	0.99352	0.995861	0.991617
C_{3-6}	0.977387	0.999085	0.987587	0.966909	0.995069	0.98906	0.992733	0.970991	1	0.983549	0.98001
C_{4-1}	0.991611	0.999985	1	0.993371	0.992635	0.994755	1	0.995429	0.998321	0.998321	0.984771
C_{4-2}	0.988131	1	0.991604	0.996471	0.990575	0.977665	0.991621	0.989716	0.989716	0.998126	0.993592
C_{4-3}	1	0.973741	0.985083	0.984601	0.986519	0.993585	0.97224	0.986069	0.982024	0.991552	0.990767
C_{4-4}	0.988879	0.993231	0.99519	0.969938	1	0.982038	0.996135	0.987729	0.985526	1	0.993231
C_{4-5}	0.995998	0.992995	0.988573	0.992404	1	0.989781	0.990002	0.999554	0.981031	0.99768	0.998314
C_{4-6}	0.987966	1	0.998779	0.98284	0.98439	0.998766	0.991069	0.994785	0.999244	0.994204	0.991297
C_{5-1}	0.98342	1	0.990632	0.999035	0.999236	0.996358	0.990108	0.995487	0.99982	0.994368	0.978196
C_{5-2}	0.988149	0.98868	0.996365	0.992738	0.999218	0.986417	0.983983	0.994621	0.996162	1	0.994621
C_{5-3}	1	0.968659	0.972805	0.985501	0.976471	0.996098	0.989881	0.9899	0.978527	0.9899	0.988961
C_{5-4}	0.980813	0.985236	0.9921	0.970282	0.987227	0.980813	1	0.986999	0.977406	0.992117	0.985236
C_{5-5}	0.993293	0.988138	0.979659	0.993109	0.982829	0.997204	0.988138	1	0.976791	1	0.995849
C_{5-6}	0.976587	0.997522	0.990449	0.973291	0.99826	0.985793	0.993142	0.983158	1	0.996016	0.986905
C_{6-1}	0.978809	0.994838	0.994219	0.964213	0.995051	0.973434	1	0.976979	1	0.993346	0.987858
C_{6-2}	0.987377	0.994345	0.981609	1	0.969657	0.995947	0.980945	0.999281	0.988137	0.998574	0.993493
C_{6-3}	1	0.968061	0.981857	0.966241	0.99218	0.98358	0.981247	0.981833	0.994444	0.995251	0.988748
C_{6-4}	0.982005	0.985763	0.979657	0.987786	0.983648	0.991201	0.981352	0.992659	0.997574	1	0.986913
C_{6-5}	0.995001	0.985999	0.971951	0.999391	0.967777	1	0.979066	0.994267	0.972381	0.998103	0.984424
C_{6-6}	0.983826	0.999156	0.999389	0.969764	0.99511	0.99534	0.996276	0.984177	1	0.986836	0.989557

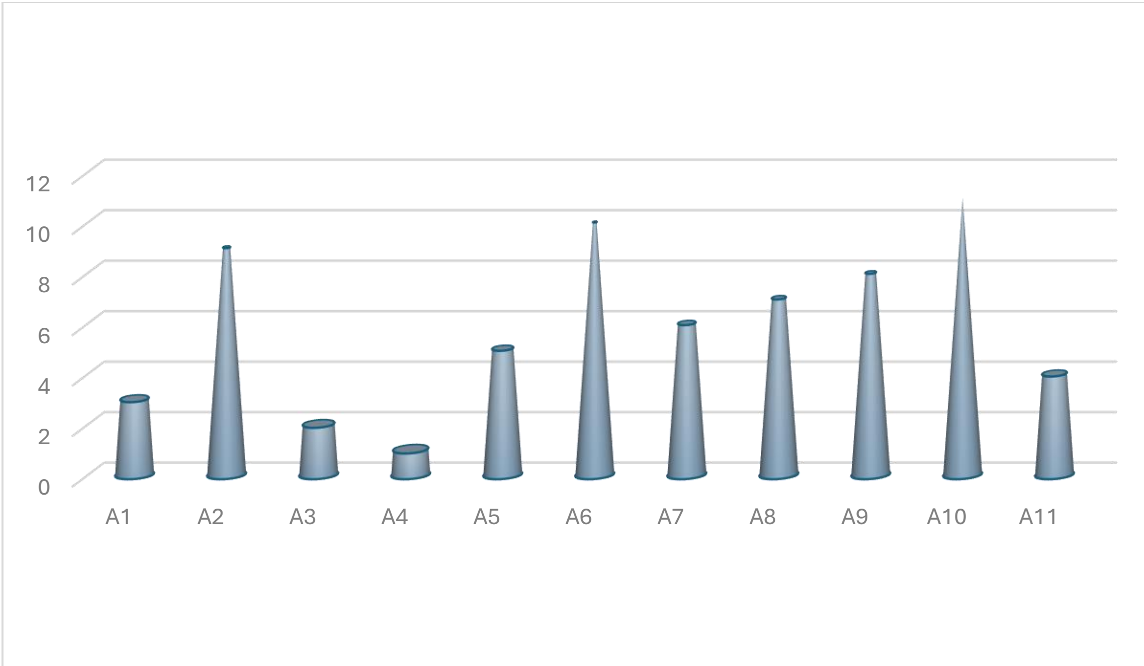

Fig 21. Rank of alternatives.

4. Conclusions

Higher education competitiveness is a multi-dimensional concept that encompasses academic quality, infrastructure, industry engagement, internationalization, and financial stability. Institutions that excel in these areas not only enhance their global reputation but also provide students with high-quality learning experience and career opportunities. By employing structured evaluation frameworks like MCDM, universities can systematically assess their strengths and weaknesses and develop strategies to improve their competitive standing. As the global education landscape continues to evolve, institutions must remain adaptable, innovative, and forward-thinking to maintain their relevance and leadership in higher education. TreeSoft set is used in this study to define relationships between the criteria and sub-criteria. CIMAS method was used to compute the criteria weights and the WASPAS method was used to rank the alternatives.

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