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Selecting Optimal Charcoal Company using Multi-Criteria Decision Making Methodology

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Abstract

A popular technique used in many industries to assist decision-makers in evaluating and selecting the best alternatives from a variety of accessible possibilities is multi-criteria decision-making (MCDM). This study proposed an MCDM methodology for selecting optimal charcoal from various options and criteria. Various criteria influence the selection problem, such as financial, safety, labour, power supply, production, and transportation. This study used the Combinative Distance Assessment (CODAS) method as an MCDM method to rank the alternatives and use the best one. This study used nine criteria and twenty alternatives. The requirements are divided into positive and negative criteria to compete for the positive and negative ideal solution using the CODAS method. The criteria weights are computed. The rank of alternatives is checked by using the sensitivity analysis. The results show the rank of other options is stable in different cases.

Keywords: Multi-Criteria Decision Making; CODAS Method; Decision Making; Selection Problem.

1 | Introduction

The amount of research released monthly by hundreds of academic publishing sites presents an increasing difficulty for researchers. A large portion of research activity is now devoted to monitoring the outcomes of studies and developing and integrating new approaches with existing resources. The idea of bounded rationality states that a researcher's rationality is constrained by the body of information that is currently accessible, the cognitive capacities of each person, and the availability of decision-making (DM) time. In this way, many scholars have benefited from the systematic process of literature evaluation using bibliometric analysis as a place to start [1-3].

Given that DM permeates all parts of life, it may be argued that it is an essential component of human activity in the context of the current study. This entails assessing each choice individually in light of the decision-

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makers (DMs) preferences, background, and other pertinent information. DMs must make various primary and complicated choices, with varied possible outcomes in both personal and professional contexts. To reach a logical choice while handling real-life situations, it is often necessary to consider various opposing viewpoints. Formally speaking, a decision is an action plan designed to solve a particular decision issue or an option made based on information that is now accessible [4-6].

A framework that can create a hierarchy of choices and differentiate between possibilities is crucial for improving the DM process. Using this framework, essential factors—also called criteria—must be found and chosen to distinguish between options. Three primary elements comprise multi-criteria decision-making (MCDM): a collection of choices, several distinct criteria, and a procedure for comparing them. Using MCDM procedures, the best alternatives are chosen from a collection of options after being evaluated according to several criteria [7-9].

Criteria weights have a significant impact on how the DM process turns out. In MCDM situations, choosing a weighting strategy is crucial since it aids in determining the relative relevance of each criterion and makes the DM process easier. Furthermore, the selection of weighting techniques is necessary for each MCDM issue as it directly impacts the precision and dependability of the decision results [10-12]. This study employed the MCDM methodology for using optimal charcoal companies.

2 | Materials and Methods

CODAS, one of the MCDM approaches used for the assessment of alternatives, is a novel method brought to the literature by Keshavarz-Ghorabaee et al., in 2016. Setting alternatives that are farther away from the negative ideal answer as priorities forms the foundation of the method's philosophy [13-15]. This section introduces the steps of the CODAS method to rank the alternatives, as shown in Figure 1.

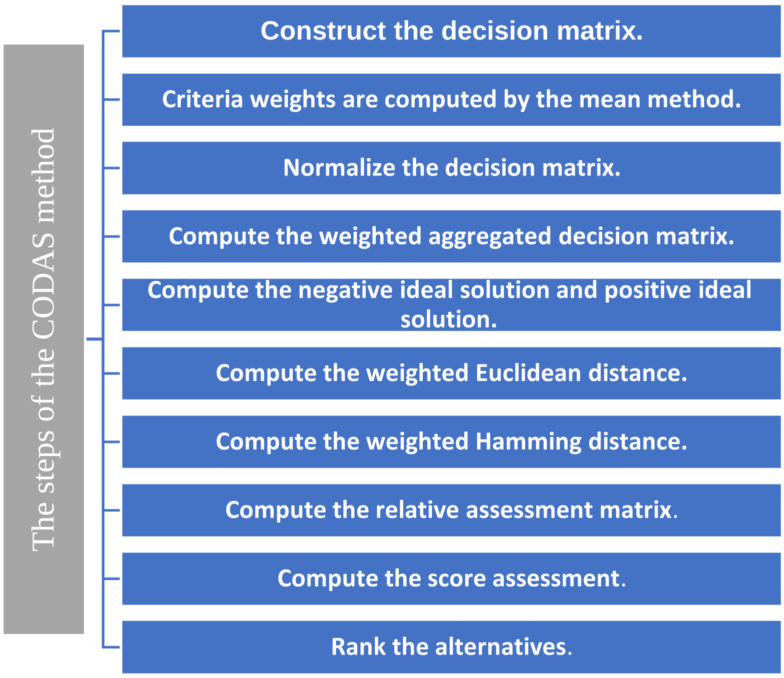

Figure 1. The steps of the CODAS method.

Step 1. Construct the decision matrix. Eq. (1) used to build the decision matrix between criteria and alternatives.

$$x_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2. Criteria weights are computed by the mean method.

Step 3. Normalize the decision matrix.

$$N_{ij} = \frac{x_{ij}}{\max x_{ij}} \quad (2)$$

$$N_{ij} = \frac{\min x_{ij}}{x_{ij}} \quad (3)$$

Step 4. Compute the weighted aggregated decision matrix.

$$r_{ij} = w_j N_{ij} \quad (4)$$

Step 5. Compute the negative ideal solution and positive ideal solutions.

$$d_j = \min r_{ij} \quad (5)$$

$$d_j = \max r_{ij} \quad (6)$$

Step 6. Compute the weighted Euclidean Distance

$$T_i = \sqrt{\sum_{j=1}^{m} \left(r_{ij} - d_j\right)^2} \quad (7)$$

Step 7. Compute the weighted Hamming Distance

$$E_i = \sqrt{\sum_{j=1}^{m} \left|r_{ij} - d_j\right|} \quad (8)$$

Step 8. Compute the relative assessment matrix.

$$A_{is} = (T_i - T_s) + \left(\rho(T_i - T_s) \times (E_i - E_s)\right) \quad (9)$$

Step 9. Compute the score of assessment.

$$S_i = \sum_{i=1}^{n} A_{is} \quad (10)$$

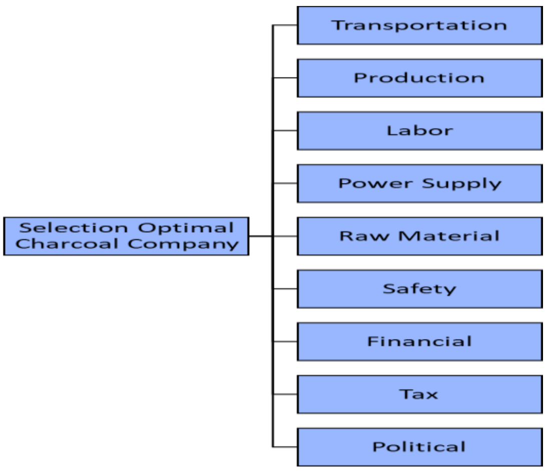

Figure 2. The list of criteria.

3 | Application

This section introduces the results of the MCDM methodology to select the best charcoal company.

Step 1. Construct the decision matrix.

Experts and decision makers are evaluated the criteria and alternative by their opinions by Eq. (1). The decision matrix is built based on the criteria and alternatives. Figure 2 shows the list of criteria.

Step 2. Criteria weights are computed by the mean method, as shown in Figure 3.

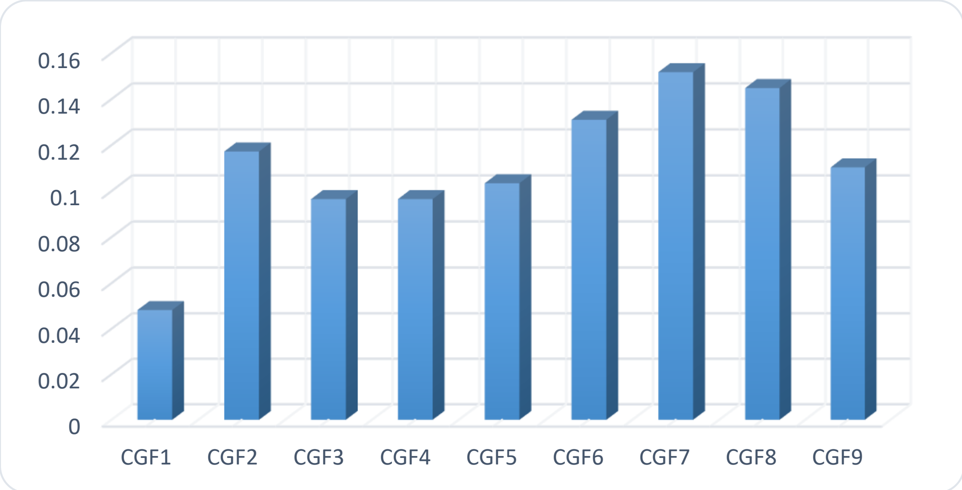

Figure 3. The criteria weights.

Step 3. Normalize the decision matrix by using Eqs. (2) and (3) as shown in Table 1.

Table 1. The normalization decision matrix.

	CGF_1	CGF_2	CGF_3	CGF_4	CGF_5	CGF_6	CGF_7	CGF_8	CGF_9
CGA_1	0.222	0.333	0.667	0.556	0.051	0.778	0.889	1.000	0.556
CGA_2	0.222	0.667	0.556	0.444	0.089	0.444	0.556	0.667	0.444
CGA_3	0.333	0.889	0.333	0.556	0.051	0.889	1.000	0.667	0.778
CGA_4	0.222	0.444	0.222	0.222	0.038	0.667	0.556	0.778	0.889
CGA_5	0.556	0.556	1.000	0.667	0.076	0.556	0.778	0.222	1.000
CGA_6	0.667	0.667	0.889	0.556	0.063	0.667	0.444	0.333	0.667
CGA_7	0.333	0.333	0.556	1.000	0.101	1.000	0.556	0.667	0.889
CGA_8	0.222	0.222	0.667	0.667	0.114	0.889	0.667	0.556	0.556
CGA_9	0.556	0.111	0.333	0.556	0.076	0.778	0.222	0.444	1.000
CGA_{10}	0.444	0.444	0.222	0.556	0.114	1.000	0.556	0.778	0.889
CGA_{11}	0.778	0.556	0.111	0.333	0.101	0.889	0.444	0.889	0.778
CGA_{12}	0.889	0.667	0.444	0.667	0.076	0.778	0.222	1.000	0.444
CGA_{13}	0.667	0.333	0.556	0.556	0.063	0.556	0.333	0.667	0.556
CGA_{14}	0.889	0.222	0.667	1.000	0.051	0.222	0.667	0.556	0.667
CGA_{15}	1.000	0.556	1.000	0.444	0.089	0.667	0.222	0.667	0.222
CGA_{16}	0.889	1.000	0.889	0.778	1.000	0.333	0.556	0.667	0.444
CGA_{17}	0.778	0.889	0.778	0.889	0.101	0.444	0.444	0.556	0.333
CGA_{18}	0.444	0.778	0.778	0.889	0.051	0.667	1.000	0.222	0.222
CGA_{19}	0.556	0.556	0.778	1.000	0.101	0.778	0.556	0.667	0.556
CGA_{20}	0.444	0.222	0.556	1.000	0.089	0.889	0.556	0.444	0.889

Step 4. Compute the weighted aggregated decision matrix by using Eq. (4) as shown in Table 2.

Table 2. The weighted normalization decision matrix.

	CGF_1	CGF_2	CGF_3	CGF_4	CGF_5	CGF_6	CGF_7	CGF_8	CGF_9
CGA_1	0.011	0.039	0.064	0.054	0.005	0.102	0.135	0.145	0.061
CGA_2	0.011	0.078	0.054	0.043	0.009	0.058	0.084	0.097	0.049
CGA_3	0.016	0.104	0.032	0.054	0.005	0.116	0.152	0.097	0.086
CGA_4	0.011	0.052	0.021	0.021	0.004	0.087	0.084	0.113	0.098
CGA_5	0.027	0.065	0.097	0.064	0.008	0.073	0.118	0.032	0.110
CGA_6	0.032	0.078	0.086	0.054	0.007	0.087	0.067	0.048	0.074
CGA_7	0.016	0.039	0.054	0.097	0.010	0.131	0.084	0.097	0.098
CGA_8	0.011	0.026	0.064	0.064	0.012	0.116	0.101	0.080	0.061
CGA_9	0.027	0.013	0.032	0.054	0.008	0.102	0.034	0.064	0.110
CGA_{10}	0.021	0.052	0.021	0.054	0.012	0.131	0.084	0.113	0.098
CGA_{11}	0.038	0.065	0.011	0.032	0.010	0.116	0.067	0.129	0.086
CGA_{12}	0.043	0.078	0.043	0.064	0.008	0.102	0.034	0.145	0.049
CGA_{13}	0.032	0.039	0.054	0.054	0.007	0.073	0.051	0.097	0.061
CGA_{14}	0.043	0.026	0.064	0.097	0.005	0.029	0.101	0.080	0.074
CGA_{15}	0.048	0.065	0.097	0.043	0.009	0.087	0.034	0.097	0.025
CGA_{16}	0.043	0.117	0.086	0.075	0.103	0.044	0.084	0.097	0.049
CGA_{17}	0.038	0.104	0.075	0.086	0.010	0.058	0.067	0.080	0.037
CGA_{18}	0.021	0.091	0.075	0.086	0.005	0.087	0.152	0.032	0.025
CGA_{19}	0.027	0.065	0.075	0.097	0.010	0.102	0.084	0.097	0.061
CGA_{20}	0.021	0.026	0.054	0.097	0.009	0.116	0.084	0.064	0.098

Step 5. Compute the negative ideal solution and positive ideal solutions by suing Eqs. (5) and (6).

Step 6. Compute the weighted Euclidean Distance by using Eq. (7).

Step 7. Compute the weighted Hamming Distance by using Eq. (8).

Step 8. Compute the relative assessment matrix by using Eq. (9).

Step 9. Compute the score of assessment by using Eq. (10) as shown in Figure 4.

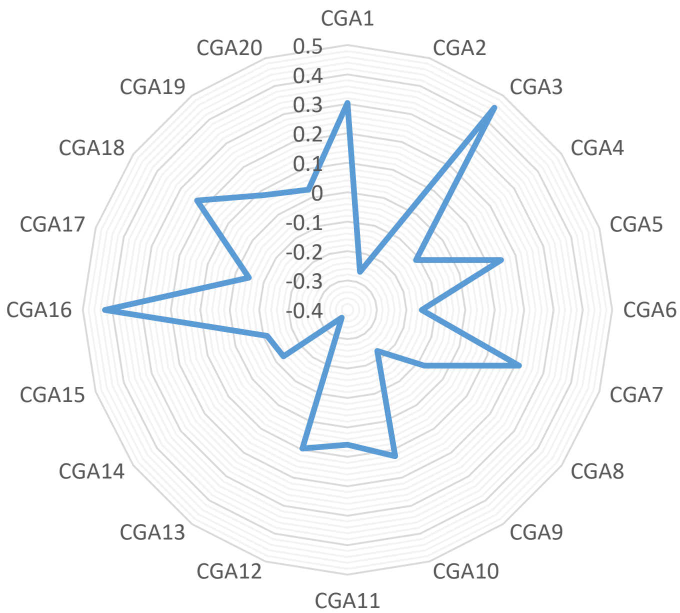

Figure 4. the values of score assessment.

4 | Sensitivity Analysis

In this section, we change the value of ρ between 0 and 1, then compute the rank of alternatives to show the rank is stable. The values of the score assessment are shown in Figure 5. The rank of alternatives is shown in Figure 6. The results show the rank is stable under different cases.

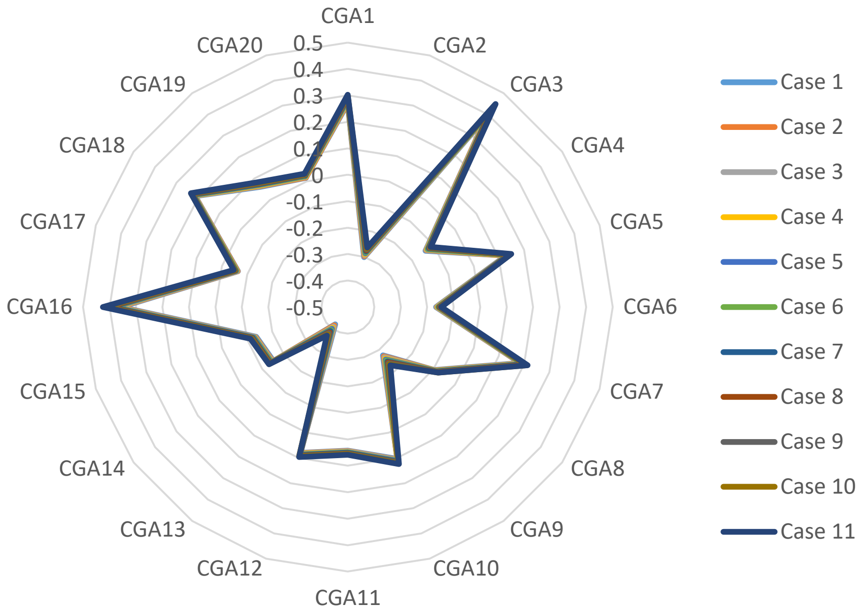

Figure 5. The values of score assessment under different cases.

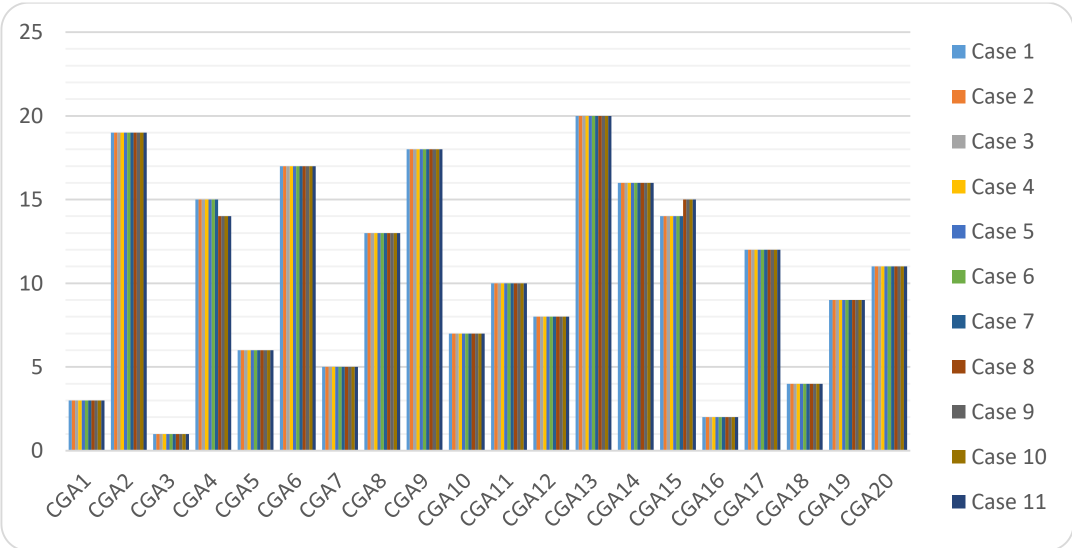

Figure 6. The rank of alternatives under sensitivity analysis.

5 | Conclusions

This study adapted a decision-making model for selecting optimal charcoal companies from various options. This study used an MCDM concept to deal with multiple criteria and rank them. This study used a set of experts and decision-makers to rank the criteria and alternatives. Expert opinions evaluate the requirements and alternatives. Then, these opinions are replaced by crisp values. This study used the mean method to compute the criteria weights. This study used nine criteria and twenty alternatives to be evaluated. The CODAS method is an MCDM method used to rank the other options. The positive and negative ideals Solutions are computed from the positive and negative criteria by the CODAS method. All requirements are positive except the financial criteria. The alternatives are ranked based on the score assessment of the CODAS method. The results show that alternative 3 is the best and alternative 13 is the worst. The sensitivity analysis is conducted to show the stability of the results.

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Author Contributaion

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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