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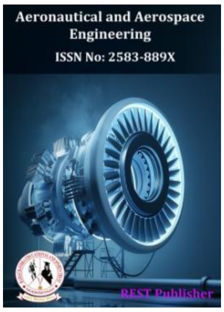

Assessment of Selecting the Most Appropriate Oilseed for Biodiesel Production Using the COPRAS Method

Vimala Saravanan, Chinnasami Sivaji, Sathiyaraj Chinnasamy, Chandrasekar Raja

REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu,India.

Corresponding Author Email: vimalarsri@gmail.com

Abstract: *Diesel resources are valuable both industrially and economically around the world. However, considerations including the diminishing supply of fossil energies and the rise in greenhouse gas emissions have accelerated research into greener alternative fuels globally. Presently, emerging nations are having difficulty supplying their expanding energy needs due to the depletion of traditional energy sources. It is essential to increase the variety of energy supplies and lessen reliance on fossil fuels by utilising substitutes to address this challenge. One of these alternate sources is biomass, which may be used to produce fluid biofuels like "bioethanol and biodiesel"."The fuel quality, engine performance characteristics, and emission outcomes of biodiesel" are the main criteria that have changed as a result of variations in the physicochemical features of the oilseeds ("soybean, cottonseed, rapeseed, and camelina"). To choose the best energy crop, these parameters were assessed using "multi-criteria decision-making (MCDM) methodologies". "COPRAS" has been used to determine the importance of each parameter and the order of the studied alternatives for this objective."Rapeseed, soybean, cottonseed, and camelina biodiesel" are respectively the top four oilseed substitutes for the manufacturing of biodiesel, according to the analysis's findings.According to the findings; "rapeseed" is the most suited oilseed for growth as an energy commodity, whereas "camelina" is the least favored option for making biodiesel.*

Keywords: *Biodiesel, Oil Seed, The fuel quality, engine performance characteristics, emission outcomes of biodiesel and MCDM.*

1. INTRODUCTION

Diesel fuels are valuable both industrially and economically around the world. However, considerations including the diminishing supply of fossil fuels and the rise in greenhouse gas emissions have accelerated research into "cleaner alternative fuels" globally. Among them, biofuels are anticipated to lessen reliance on fossil energy as well as the buildup of "pollutants and greenhouse gases". Additionally, a variety of renewable power can be used to manufacture these fuels [1,2].Developing nations are currently striving to meet their expanding energy requirements in the face of steadily depleting traditional energy resources. It is imperative to broaden the range of energy sources and lessen our reliance on oil by utilising options to get over this challenge. Biomass is one of these alternate sources that can be used to produce liquid renewables like "bioethanol and biodiesel" [3,4].A sustainable, recyclable fuel made locally from "vegetable oils, animal fats, or used restaurant grease" is called biodiesel. The Green Fuel Standard's "biomass-based diesel and overall improved biofuel requirements" are both satisfied by biodiesel [5].Renewability, improved lubricity, and safe handlings among the benefits of biodiesel are its "high flash point, biodegradability, high combustion efficiency, and usage without engine changes". However, when utilised as a fuel, biodiesel has significant drawbacks including "high viscosity, low energy content, increased cold flow characteristics, higher NOx emissions, and reduced engine speed and power" [6].Various countries are looking for alternative vegetable biodiesel as alternatives to diesel fuel based on their climate and soil circumstances: "soybean oil in the USA, rapeseed and sunflower oils in Europe, palm oil in south-east Asia, and coconut oil in the Philippines" are all considered alternatives to petroleum diesel [7].The utilisation of edible crude oil for biodiesel manufacturing, such as "mustard, soya bean, sunflower, and palm oil," puts food in direct rivalry, and on top of that, the necessity for edible oils is met by shipping from other nations. The sole alternative for manufacturing biodiesel generation and oil extraction for the function of the engine appears to be non-edible oil resources.The usage of renewable energy sources is receiving more attention from researchers and technologists worldwide due to the social and environmental difficulties related to the use of fossil fuels for transit and electric generation. Given the need for fossil fuels and their impact on the climate, it is imperative to consider alternative energy sources that can not only replace traditional energy sources but also maintain a pollution-free atmosphere and provide a long-term resolution [8,9].Renewable energy sources come in many different forms, including "solar, wind, hydropower, ocean thermal energy, geothermal energy, wave energy, biomass, and bioenergy, among others". To lessen reliance on "fossil fuels and environmental pollution problems", it is imperative to expand the renewable resource and boost their use. When the supply of fossil fuels runs out, these green sources of energy will become increasingly crucial [10,11].One of the significant sources of renewable power is "biomass and bioenergy". Vegetable/plant oils, both consumable and non-edible, can be used to make biodiesel from a variety of sources. It is not advisable to produce biodiesel from consumable oil crops since doing so raises many ethical issues and has led to well-known arguments on whether food should be considered fuel [12].It is not feasible for biodiesel, which is made from "food-grade vegetable oils, to compete economically with fossil-based diesel" due to its high cost. One of the main sources of renewable biofuel is less-priced, non-edible crop oil or vegetable oil that might be used as a feedstock for biofuel manufacturing [13]."The fuel quality, engine performance characteristics, and emission outcomes of biodiesel" are the main criteria that have changed as a result of variations in the "physicochemical properties of the oilseeds (soybean, cottonseed, rapeseed, and camelina)". To choose the best energy crop, these parameters were assessed using "multi-criteria decision-making (MCDM) methodologies". COPRAS has been used to determine the importance of each condition and the ranks of the studied alternatives for this goal.

2. MATERIALS AND METHODS

"Complex Proportional Assessment (COPRAS)", a rating method, was developed by "Zavadskas, Kaklauskas, and Sarka in 1994". This method considers both the best and worst outcomes independently. Finding "both the optimal best solution and the ideal worst solution" allows one to select the best alternative value. This is frequently utilised in engineering field problem situations for evaluating and choosing different projects. The fundamental goal of the COPRAS technique is to rank each alternative by applying the proper weights to each parameter [14,15]. "COPRAS MCDM" offers numerous noteworthy excellent aspects that more than make up for its few small drawbacks. The ability of "COPRAS" to handle beneficial and negative factors individually is its primary and most important advantage [16]. According to "COPRAS", a set of criteria determines the significance and applicability degree of the variants being considered. The variables, along with the weights and amounts of each standard, are effectively specified by these criteria. These core concepts show that the "COPRAS approach" is an essential "MCDM technique" and a useful judgement instrument [17]. By utilising a single evaluation technique that takes into account "the effects of both the cost and advantage type criteria" COPRAS rates options. By taking into consideration "the utility degree of options," which refers to a percentage and reflects the degree to which one conclusion is better than or worse than the numerous possibilities utilised for evaluation, COPRAS varies from those other MCDM techniques [18]. A recent study has also demonstrated that COPRAS is more dependable than WSM in the event of new data, and assessments incorporated with COPRAS are significantly more exact and less biased than outcomes with "TOPSIS and WSM". Another benefit COPRAS offers over some other MCDM software, such as "PROMETHEE, DEA, VIKOR, AHP, and ELECTRE" is that it uses a very straightforward and straightforward MCDM approach that takes a lot less processing work and has a high likelihood of graphical interpretation [19,20].

Step 1: The decision matrix X, which displays how various options perform about certain criteria, is created.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \qquad (1)$$

Step 2: Weights for the criteria are expressed as

$$w_j = [w_1 \cdots w_n], \qquad (2)$$

$$\sum_{j=1}^{n} (w_1 \cdots w_n) = 1$$

the sum of the weight distributed among the evaluation parameters must be one.

Step 3: The matrix x_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \quad (3)$$

Step 4: Weighted normalized matrix N_{ij} is calculated by the following formula

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

Step 5: sum of benefit criteria and the sum of cost criteria are calculated by following equations 5 and 6 respectively.

$$B_i = \sum_{j=1}^{k} N_{ij} \quad (5)$$

$$C_i = \sum_{j=k+1}^{m} N_{ij} \quad (6)$$

Step 6: The relative importance of the choices should be determined. Calculations of alternative significance are based on Q_i. Higher the value of Q_i, the better the response. Alternatives with the highest Q_i value are $Q_{(max)}$. The following is a Qi equation:

$$Q_i = B_i + \frac{\min(C_i) \times \sum_{i=1}^{n} C_i}{C_i \times \sum_{i=1}^{n} \left(\frac{\min(C_i)}{C_i}\right)} \quad (7)$$

Step 7: Next U_i is calculated.

$$U_i = \frac{Q_i}{\max(Q_i)} \times 100\% \quad (8)$$

The greatest connected relative importance is Cmax. If a selection's utility functionality rises or falls depends on its relative importance value. You can achieve a utility rating of "between 0% and 100%". In a situation when there are many factors to consider, this method permits the examination of "operational features, utility stages of weight, and instantaneous and relative relevance" [21,22]. "The quality of the fuel, the features of engine performance, and the results of biodiesel emission testing" have all changed significantly as a result of the various physicochemical qualities of the oilseeds "(soybean, cottonseed, rapeseed, and camelina)". Therefore, to choose the most appropriate energy crop, these characteristics were assessed using multi-criteria decision-making (MCDM) methodologies. The weights of the researched options and the relevance of each parameter have been determined for this reason using COPRAS.

3. ANALYSIS AND DISCUSSION

TABLE 1. Material Properties

Biodiesel	Cetane Number	Viscosity	Torque	BSFC	CO	HC
Rapeseed	9	7	9	8	8	4
Camelina	3	8	4	2	5	9
Soybean	8	6	8	7	9	5
Cottonseed	7	9	3	3	6	3

Table 1 shows the data set for "fuel quality, engine performance characteristics and emission results" of each alternate bio seed. "Rapeseed, Camelina, Soybean and Cottonseed" are taken as alternate materials in this research. "Viscosity, cetane number, torque, brake specific fuel consumption, Production of air polluting gas such as NOx, and the emission of hydrocarbons" are evaluated for the picking of bio seeds.

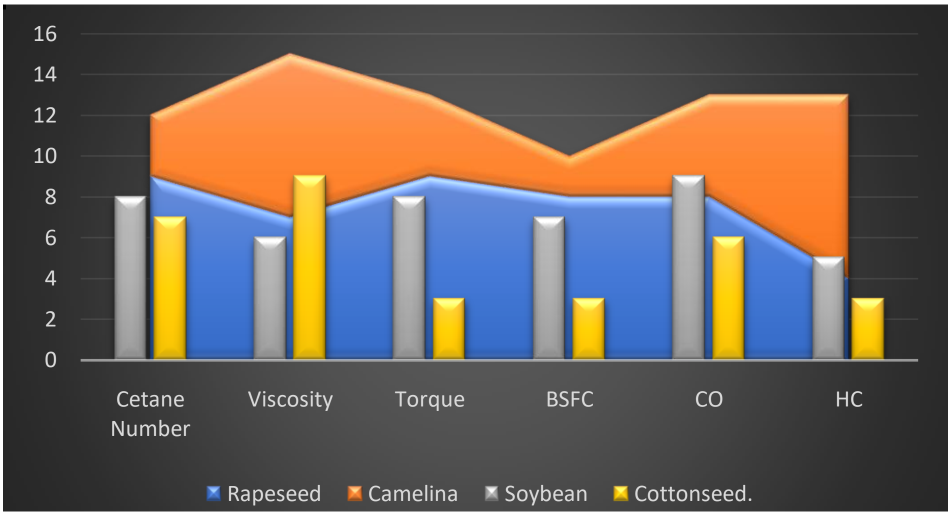

FIGURE 1. parameters of Energy source

Figure 1 show the The illustrates the data set for "fuel quality, engine performance characteristics and emission results of each alternate bio seeds". "Rapeseed, Camelina, Soybean and Cottonseed" are taken as alternate materials in this research. "Viscosity, cetane number, torque, brake specific fuel consumption, Production of air polluting gas such as NOx, and the emission of hydrocarbons" are evaluated for the picking of bio seeds.

TABLE 2. Normalized matrix

0.3333	0.2333	0.3750	0.4000	0.2857	0.1905
0.1111	0.2667	0.1667	0.1000	0.1786	0.4286
0.2963	0.2000	0.3333	0.3500	0.3214	0.2381
0.2593	0.3000	0.1250	0.1500	0.2143	0.1429

Table2 The normalized matrix of Performance Ratings of parameters of each bio seed is displayed in Table 2 above. Equation 3 was used to create this matrix.

TABLE 3. Weight Distribution

0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
0.166667	0.166667	0.166667	0.166667	0.166667	0.166667

Table3 The preferred weight for the evaluation parameters is shown in Table 3. In this case, weight is equally distributed among evaluation criteria and the sum of weight distributed is one.

TABLE 4. Weighted normalized decision matrix

0.05556	0.03889	0.06250	0.06667	0.04762	0.03175
0.01852	0.04444	0.02778	0.01667	0.02976	0.07143
0.04938	0.03333	0.05556	0.05833	0.05357	0.03968
0.04321	0.05000	0.02083	0.02500	0.03571	0.02381

Table4 The Performance Ratings of the parameters of each bio seed are shown in Table 4 as a normalized matrix. Equation 4 was used to calculate this matrix, which was produced by multiplying tables 2 and 3.

TABLE 5. the sum of benefit criteria and the sum of cost criterion

Biodiesel	Bi	Ci
Rapeseed	0.223611	0.079365
Camelina	0.107407	0.101190
Soybean	0.196605	0.093254
Cottonseed.	0.139043	0.059524

Table 5 displays the total cost and total benefit criteria that were determined using equations 5 and 6. "Rapeseed, Camelina, Soybean and Cottonseed" are used to optimize the Comprehensive Performance of each bio seed**.**

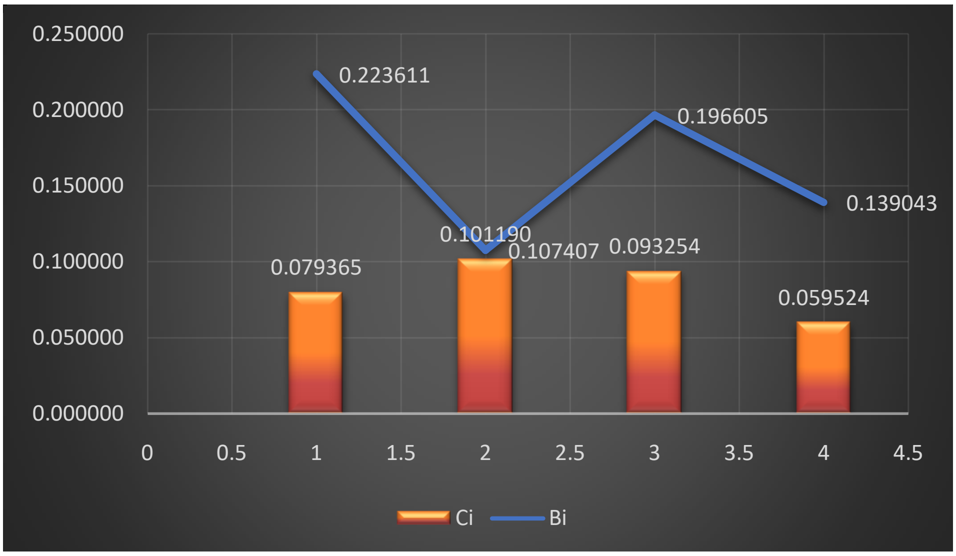

FIGURE 2. Bi and Ci

Equations 5 and 6 were used to calculate the total beneficial criteria and total cost criterion shown in Figure 2. “Rapeseed, Camelina, Soybean and Cottonseed” are used to evaluate the Comprehensive Performance of selected bio seeds**.**

TABLE 6. Relative significance and Utility degree

Biodiesel	Qi	Ui
Rapeseed	0.30760	100.0000
Camelina	0.17328	56.3333
Soybean	0.26809	87.1537
Cottonseed	0.25103	81.6090

Table6 Using equations 7 and 8, Table 6 displays the relative relevance and utility degree. Here utility degree value for Rapeseed is hundred, Camelina is 56.3333, Soybean is 87.1537 and Cottonseed is 81.6090.

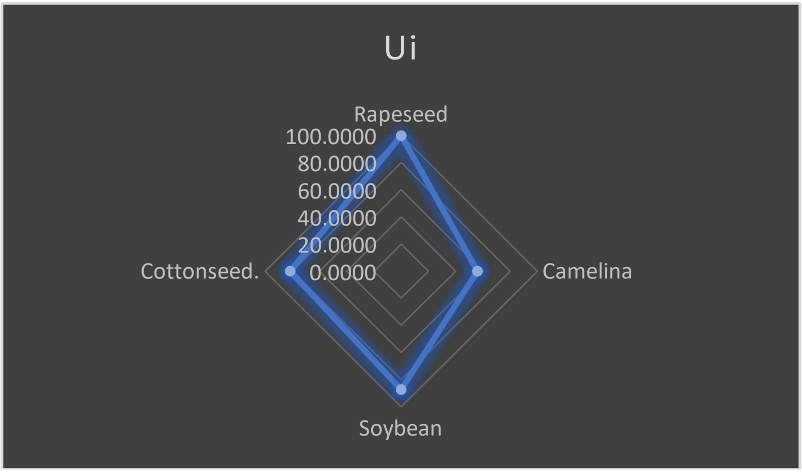

FIGURE 3. Utility Degree

Figure 3 shows the illustration of the Relative significance and Utility degree calculated by using equations 7 and 8. Here utility degree value for Rapeseed is hundred, Camelina is 56.3333, Soybean is 87.1537 and Cottonseed is 81.6090.

TABLE 7. Rank

Biodiesel	Rank
Rapeseed	1
Camelina	4
Soybean	2
Cottonseed	3

Table 7 shows the rank of alternatives “Rapeseed, Camelina, Soybean and Cottonseed” using utility degree values in table 6. Here rank of alternatives using the COPRAS method for Rapeseed is first, Camelina is fourth, Soybean is second and Cottonseed is third.

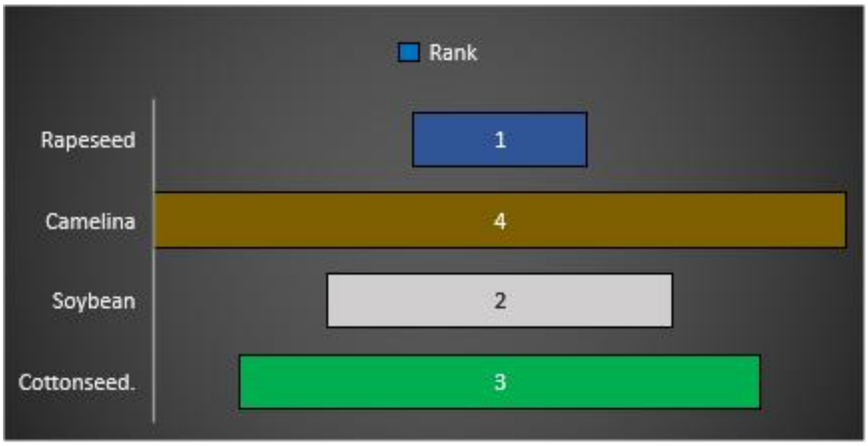

FIGURE 4. Rank

Figure 4 illustrates the ranking of Ui from Table 6. Here rank of alternatives using the COPRAS method “Rapeseed is first, Camelina is fourth, Soybean is second and Cottonseed is third”. “Rapeseed, soybean, cottonseed, and camelina biodiesel” are the top four oilseed substitutes for the manufacturing of biodiesel, according to the analysis's findings.According to the findings, “rapeseed” is the most suited oilseed for development as an energy crop, whereas “camelina” is the least favored option for making biodiesel.

4. CONCLUSION

Energy independence is essential for India's and other emerging nations' overall economic development. The necessity to look for alternate, safe, clean, and renewable sources have been given major attention. Additional risks to developing nations' economies include erratic supplies and regular price increases of fossil fuels on the global market.In India, the need for transportation fuel is steadily rising. On either hand, the expense of fossil fuels is frequently rising, and the global market's availability is unstable. We must switch to renewable and environmentally friendly biodiesel to reduce the supply of crude oil. Pongamia oil has the potential to be used to produce biofuels, which are safe, clean, and sustainable. Addressing the demand for energy and organic fertilizer has enormous promise for India's rural areas. Of course, works are to be conducted on Pongamia to "standardize agro-technology, low cost and efficient mechanical device to expel oil, to figure out the economics, high yielding and high oil content varieties" compatible to the varied agribusiness of India.Utilizing renewable energy sources is one of the new energy strategies for developing nations. Biodiesel is a promising substitute for current fossil fuel use among renewable energy resources.This paper utilizes the "COPRAS MCDM model" for analyzing four distinct biodiesel products made from energy crops in terms of their "fuel characteristics, engine performance, and exhaust emissions". " Rapeseed, soybean, cottonseed, and camelina biodiesel" are the top four oilseed substitutes for the manufacturing of biodiesel, according to the analysis's findings.According to the findings, “rapeseed” is the most suited oilseed for development as an energy crop, whereas “camelina” is the least favored option for making biodiesel.

REFERENCES

[1]. Mukhtar, Ahmad, Sidra Saqib, Hongfei Lin, MansoorUl Hassan Shah, Sami Ullah, Muhammad Younas, Mashallah Rezakazemi et al. "Current status and challenges in the heterogeneous catalysis for biodiesel production." Renewable and Sustainable Energy Reviews 157 (2022): 112012.

[2]. Bashir, Muhammad Aamir, Sarah Wu, Jun Zhu, AnilkumarKrosuri, Muhammad Usman Khan, and Robinson Junior Ndeddy Aka. "Recent development of advanced processing technologies for biodiesel production: A critical review." Fuel Processing Technology 227 (2022): 107120.

[3]. Babadi, Arman Amani, Shahrooz Rahmati, RafiehFakhlaei, Bahram Barati, Shuang Wang, William Doherty, and KostyaOstrikov. "Emerging technologies for biodiesel production: Processes, challenges, and opportunities." Biomass and Bioenergy 163 (2022): 106521.

[4]. Zhang, Youhua, LinhaiDuan, and Hossein Esmaeili. "A review on biodiesel production using various heterogeneous nanocatalysts: Operation mechanisms and performances." Biomass and Bioenergy 158 (2022): 106356.

[5]. Esmaeili, Hossein. "A critical review on the economic aspects and life cycle assessment of biodiesel production using heterogeneous nanocatalysts." Fuel Processing Technology 230 (2022): 107224.

[6]. Yaashikaa, P. R., P. Senthil Kumar, and S. Karishma. "Bio-derived catalysts for production of biodiesel: A review on feedstock, oil extraction methodologies, reactors and lifecycle assessment of biodiesel." Fuel 316 (2022): 123379.

[7]. Prabakaran Nanjundan, M. Ramachandran, Manjula Selvam, Kurinjimalar Ramu, "The survey of GSM Wireless Data Communication System using the SPSS Method", Computer Science, Engineering and Technology, 1(1), March 2023, 19-27.

[8]. Minu, R. I., Martin Margala, S. Siva Shankar, Prasun Chakrabarti, and G. Nagarajan. "Early-stage esophageal cancer detection using hybrid quantum CNN." *Soft Computing* (2023): 1-6.

[9]. Demirbas, Ayhan. "Political, economic and environmental impacts of biofuels: A review." Applied energy 86 (2009): S108-S117.

[10]. Kralova, Iva, and Johan Sjöblom. "Biofuels–renewable energy sources: a review." Journal of Dispersion Science and Technology 31, no. 3 (2010): 409-425.

[11]. Dwivedi, Gaurav, Siddharth Jain, and Mahendra Pal Sharma. "Pongamia as a source of biodiesel in India." Smart Grid and Renewable Energy 2, no. 3 (2011): 184-189.

[12]. Padhi, Saroj K., and R. K. Singh. "Non-edible oils as the potential source for the production of biodiesel in India: a review." Journal of chemical and pharmaceutical Research 3, no. 2 (2011): 39-49.

[13]. Dixit, Savita, and A. Rehman. "Linseed oil as a potential resource for bio-diesel: a review." Renewable and Sustainable Energy Reviews 16, no. 7 (2012): 4415-4421.

[14]. M. Ramachandran, Kurinjimalar Ramu, Chinnasami Sivaji, Chandrasekar Raja, "Future Technology Development Using VIKOR Method", Computer Science, Engineering and Technology, 1(1), March 2023, 28-35.

[15]. Patel, Nikul K., Padamanabhi S. Nagar, and Shailesh N. Shah. "Identification of non-edible seeds as potential feedstock for the production and application of bio-diesel." Energy and power 3, no. 4 (2013): 67-78.

[16]. Shrirame, Hemant Y., N. L. Panwar, and B. R. Bamniya. "Bio diesel from castor oil-a green energy option." Low Carbon Economy 2, no. 1 (2011): 1.

[17]. Km, R., and S. Shankar. "Secure image transformation using remote sensing encryption algorithm." *Int. J. Sci. Eng. Res* 5 (2014).

[18]. AYDIN, Yüksel. "A hybrid multi-criteria decision making (MCDM) model consisting of SD and COPRAS methods in performance evaluation of foreign deposit banks." Equinox Journal of Economics Business and Political Studies 7, no. 2 (2020): 160-176.

[19]. Goswami, ShankhaShubhra, and Dhiren Kumar Behera. "Solving material handling equipment selection problems in an industry with the help of entropy integrated COPRAS and ARAS MCDM techniques." Process Integration and Optimization for Sustainability 5, no. 4 (2021): 947-973.

[20]. Kizielewicz, Bartłomiej, Jakub Więckowski, AndriiShekhovtsov, EwaZiemba, JarosławWątróbski, and WojciechSałabun. "Input data preprocessing for the MCDM model: COPRAS method case study." (2021).

[21]. Kogila, P. "Prevention of home accidents among mothers of toddler." *The Journal of Nursing Trendz* 8, no. 3 (2017): 15-17.

[22]. Goswami, ShankhaShubhra, Dhiren Kumar Behera, Asif Afzal, Abdul RazakKaladgi, Sher Afghan Khan, Parvathy Rajendran, Ram Subbiah, and Mohammad Asif. "Analysis of a robot selection problem using two newly developed hybrid MCDM models of TOPSIS-ARAS and COPRAS-ARAS." Symmetry 13, no. 8 (2021): 1331.

[23]. Kustiyahningsih, Yeni, and IsmyQorryAini. "Integration of FAHP and COPRAS method for new student admission decision making." In 2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE), pp. 1-6. IEEE, 2020.

[24]. Vishwanath, K.S., Balaguru, S. (2020). Modeling of Flow-Induced Vibration Response of Heat Exchanger Tube with Fixed Supports in Cross Flow. In: Yang, LJ., Haq, A., Nagarajan, L. (eds) Proceedings of ICDMC 2019. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-15-3631-1_59

[25]. Rathor, Ketan, Sushant Lenka, Kartik A. Pandya, B. S. Gokulakrishna, Susheel Sriram Ananthan, and Zoheib Tufail Khan. "A Detailed View on industrial Safety and Health Analytics using Machine Learning Hybrid Ensemble Techniques." In *2022 International Conference on Edge Computing and Applications (ICECAA)*, pp. 1166-1169. IEEE, 2022.

[26]. Selvan Chenni Chetty, Thirumalai, Vadim Bolshev, Siva Shankar Subramanian, Tulika Chakrabarti, Prasun Chakrabarti, Vladimir Panchenko, Igor Yudaev, and Yuliia Daus. "Optimized Hierarchical Tree Deep Convolutional Neural Network of a Tree-Based Workload Prediction Scheme for Enhancing Power Efficiency in Cloud Computing." *Energies* 16, no. 6 (2023): 2900.

[27]. Aswini, S., S. Tharaniya, R. J. Joey Persul, B. Avinash Lingam, and P. Kogila. "Assessment of Knowledge, Attitude and Practice on Immunization among Primi Mothers of Children." *Indian Journal of Public Health Research & Development* 11, no. 3 (2020).

[28]. Rathor, Ketan, Keyur Patil, Mandiga Sahasra Sai Tarun, Shashwat Nikam, Devanshi Patel, and Sasanapuri Ranjit. "A Novel and Efficient Method to Detect the Face Coverings to Ensurethe Safety using Comparison Analysis." In *2022 International Conference on Edge Computing and Applications (ICECAA)*, pp. 1664-1667. IEEE, 2022.

[29]. VimalaSaravanan, Chinnasami Sivaji, Sathiyaraj Chinnasamy, Chandrasekar Raja, " Using the COPRAS Methodology Cancer with a solution" Computer Science, Engineering and Technology, 1(1), March 2023, 36-45.

[30]. Patel, Arpan, Shubham Jha, Rohan Soni, and Kishan Fuse. "Comparative study of MCDM techniques COPRAS and TOPSIS for selection of electric motorcycles." In Proceedings of the 2020 IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA), Bangkok, Thailand, pp. 16-21. 2020.

[31]. Jisha, L., P. Jayaprabha, S. Gnanawel, K. Gowtham Kumar, and P. Kogila. "Assessment of the Prevalence of Febrile Seizure and Associated Factors among Children: A Retrospective Study." *EXECUTIVE EDITOR* 11, no. 03 (2020): 3179.

[32]. Hezer, Seda, EmelGelmez, and ErenÖzceylan. "Comparative analysis of TOPSIS, VIKOR and COPRAS methods for the COVID-19 Regional Safety Assessment." Journal of infection and public health 14, no. 6 (2021): 775-786.

[33]. Thakur, Parul, BartłomiejKizielewicz, NeerajGandotra, AndriiShekhovtsov, Namita Saini, ArshamBorumandSaeid, and WojciechSałabun. "A new entropy measurement for the analysis of uncertain data in mcda problems using intuitionistic fuzzy sets and copras method." Axioms 10, no. 4 (2021): 335.

[34]. Tasisa, Yirgalem Bekele, and Kogila Palanimuthu. "Psychosocial Impacts of Imprisonment among Youth Offenders in Correctional Administration Center, Kellem Wollega Zone, Ethiopia." Medico-legal Update 21, no. 2 (2021).

[35]. Rathor, Ketan. "Impact of using Artificial Intelligence-Based Chatgpt Technology for Achieving Sustainable Supply Chain Management Practices in Selected Industries." *International Journal of Computer Trends and Technology* 71, no. 3 (2023): 34-40.

[36]. . Kaimkuriya, A., Balaguru, S. (2023). Experimental Investigations on Al 1100 Sheet Metal Using Deep Drawing Technique Through Conical Die Without Blank Holder. In: Sethuraman, B., Jain, P., Gupta, M. (eds) Recent Advances in Mechanical Engineering. STAAAR 2022. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-99-2349-6_18.

[37]. Kumar, Ashish, Ketan Rathor, Snehit Vaddi, Devanshi Patel, Preethi Vanjarapu, and Manichandra Maddi. "ECG Based Early Heart Attack Prediction Using Neural Networks." In *2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC)*, pp. 1080-1083. IEEE, 2022.

[38]. Kumari, Reetu, and Arunodaya Raj Mishra. "Multi-criteria COPRAS method based on parametric measures for intuitionistic fuzzy sets: application of green supplier selection." Iranian journal of science and technology, Transactions of Electrical Engineering 44, no. 4 (2020): 1645-1662.

[39]. Palanimuthu, Kogila. "Birhanu Gutu, Leta Tesfaye, BuliYohannis Tasisa, Yoseph Shiferaw Belayneh, Melkamu Tamiru, and Desalegn Shiferaw." Assessment of Awareness on COVID-19 among Adults by Using an Online Platform: 26 Countries View."." *Medico-legal Update* 21.

[40]. Krishna, S. Rama, K. Rathor, J. Ranga, and A. Soni. "S. D and AK N,"." In *Artificial Intelligence Integrated with Big Data Analytics for Enhanced Marketing," 2023 International Conference on Inventive Computation Technologies (ICICT), Lalitpur, Nepal*, pp. 1073-1077. 2023.

[41]. Selvan Chenni Chetty, Thirumalai, Vadim Bolshev, Siva Shankar Subramanian, Tulika Chakrabarti, Prasun Chakrabarti, Vladimir Panchenko, Igor Yudaev, and Yuliia Daus. "Optimized Hierarchical Tree Deep Convolutional Neural Network of a Tree-Based Workload Prediction Scheme for Enhancing Power Efficiency in Cloud Computing." *Energies* 16, no. 6 (2023): 2900.

[42]. Balaguru S &Manoj Gupta 2021, Hardfacing studies of Ni alloys: A Critical Review, Journal of Materials Research and Technology (ISSN: 2238-7854) vol. 10, pp: 1210- 1242. https://doi.org/10.1016/j.jmrt.2020.12.026.

[43]. DeenadayalanG, Balaguru S, Vijay 2018, „Standard task duration calculation and Ergonomic Analysis of Human Jack in Engine Assembly", International Journal of Pure and Applied Mathematics, vol. 119, 16003-16009.