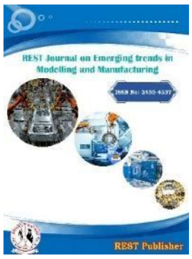
REST Journal on Emerging trends in Modelling and Manufacturing
Vol: 9(4), December 2023
REST Publisher; ISSN No: 2455-4537
Website: https://restpublisher.com/journals/jemm/
DOI: https://doi.org/10.46632/jemm/9/4/1



Evaluating Sustainable Aviation Fuel Production Technologies: A Strategic Analysis Using the WASPAS Method

***Sathiyaraj Chinnasamy, M. Ramchandran, Vimala Saravanan, Manjula Selvam**
REST Labs, Kaveripattinam, Krishnagiri, Tamil Nādu, India.
Corresponding Author Email: sathiyarajrsri@gmail.com

Abstract. *Over the past 25 years, international passenger air traffic has tripled, and this rapid growth is expected to continue for the next 25 years. While the expansion of the aviation sector brings significant economic benefits, it also poses substantial social and environmental challenges. To address these, a "sustainable aviation policy" has been proposed as a "balanced plan" that seeks to mitigate the environmental impacts of the sector's growth while acknowledging its economic advantages. However, this definition of "sustainable aviation" is contested by various organizations, and there is little agreement between non-governmental organizations and the aviation industry. Consequently, the concept of a "standard aviation policy" remains in dispute, with different parties attempting to modify it to align with their respective goals. To develop policies for sustainable aviation, competing environmental discourses have been identified and analyzed using a classification exercise supported by rhetorical, stylistic, and thematic analysis. The Analytic Hierarchy Process (AHP) is one approach used for multi-attribute decision-making that satisfies the consistency requirements of each reciprocal matrix. Recently, the "Weighted Aggregates Sum Product Assessment System" (WASPAS) has been introduced in the literature, combining the weighted product sum and basic aggregate weighting methods.*
Keywords: *international passenger air traffic, analytical hierarchy process (AHP), Sustainable Aviation, Life Cycle Analysis (LCA), Waspas.*

1. INTRODUCTION

The International Civil Aviation Organization (ICAO) reports on aviation fuel consumption and emissions trends that affect the climate, considering the contributions of aviation technology, improved air traffic control, operational advancements, and the deployment of sustainable aviation fuels (SAF). According to ICAO, the demand for SAF could potentially be fully met by 2050, resulting in a 63% reduction in emissions. Achieving this level of fuel production, however, would require substantial financial investments in the infrastructure necessary for SAF production and strong political support. Despite these efforts, achieving carbon-neutral growth post-2020 remains unlikely.

Schilling et al. (2016) examine the benefits, challenges, and emissions associated with integrating new technologies and fuels into aircraft fleets, including Fischer-Tropsch kerosene, composite wing bodies, all-electric aircraft, strut-braced wings with open rotors, and alternative fuels like liquefied natural gas. The "Weighted Aggregate Product Assessment (WASPAS)" method, although relatively new, has gained extensive usage in the literature since its introduction in 2012. It is considered superior to both the "Weighted Sum Model (WSM)" and the "Weighted Product Model (WPM)" because it allows for more precise and detailed performance evaluations, yielding a more reliable composite solution than simply summing individual components.

The literature also explores various extensions of the WASPAS method that incorporate fuzzy sets, such as human neutrosophic sets, interval-valued hesitant fuzzy sets, and interval type-2 fuzzy sets. The Analytic Hierarchy Process (AHP) is a widely recognized technique in multi-criteria decision-making (MCDM) methods for determining the weights of assessment criteria through pairwise comparisons. The WASPAS method, on the other hand, is valued for its quantitative simplicity and ability to provide more accurate results compared to other basic MCDM methods. To overcome the issue of lacking criterion weights in WASPAS, the AHP method can be integrated. By combining these two approaches, researchers can create a hybrid model that offers rational and acceptable outcomes for solving MCDM problems, such as selecting optimal locations.

2. SUSTAINABLE AVIATION

The use of "sustainable aviation fuels" is one of the most alluring ways to cut CO2 emissions in a reasonably short amount of time (SAF). For usage in current aircraft, they must match the quality and characteristics of conventional jet fuel. Because manufactures should not have to remodel aircraft or engines, and because fuel providers and airports will not have to create new fuel distribution systems, this factor is especially important. The aviation sector has some disadvantages from a technical standpoint for introducing drop-in fuels due to improved homogeneity in current aircraft, engines, and fuel standards. This is the other primary justification for employing these fuels. Using alternative fuels could be another way to lessen aviation's carbon footprint. A synthesis of different biofuels generated from plant-based resources, "sustainable aviation fuel (SAF)" is a fuel that is carbon-neutral. Due to their potential to lower greenhouse gas emissions, biofuels are a prospective replacement for petroleum fuels, which are currently utilised in commercial aircraft. Some SAFs made from fats, oils, agricultural waste, and improper waste management are legal in India. The effects of SAF manufacturing on the environment have been the subject of several research. In the most recent "Life Cycle Analysis (LCA)" study, reducing GHG emissions and improving energy efficiency were regarded as two crucial criteria. According to their findings, some SAF conversion processes need more energy than by using wastes and leftovers as a feedstock.

In a research conducted Staples et al. (2018), emission reductions through SAF production through non-food2 food goods were examined over all of the products' life cycles and several conversion methods. According to the research, it will take about $12 billion in investments annually to reduce GHG emissions to 50% or less by 2050. Other studies have looked at a constituent and process evaluation in addition to various feedstocks and conversion methods. Ganguli et al. (2018) conducted an LCA research on a lumber feed for SAF production. When compared to traditional jet fuel, it was discovered that the manufacture of SAF might reduce global warming effects by 78%. Similarly, Fortier et al. assessed the HTL of microalgae feedstock. There are two different manufacturing plants. According to their investigation, fuel generated in a traditional refinery has a higher concentration of GHGs than SAF manufactured in a sewerage system. Furthermore, Seber et al. (2014) performed LCA to assess Energy and greenhouse savings and manufacturing cost linked with HEFA jet form yellow yellow and fat. Comparing LCA of SAF made from yellow grease to petroleum-based jet fuel, the former produced reduced GHG emissions. Additionally, compared to SAF as a feedstock, SAF generated from yellow gasoline offers a lower "minimum selling price (MSP)". SAFs have the ability to diminish GHG emissions in aviation, according to LCA studies. However, due to the variability of the environment, the result of such research cannot be compared because each report makes its own unfounded assumptions system limits. Sgouridis et al. employed a continuous-time simulation approach, which was last from a primary standpoint. To examine the impact of brief policies and initiatives on eliminating CO2 emissions on global aviation. According to the report, utilising poor fuels and an emissions reductions mechanism together could help achieve the goal of lowering emissions.

3. WASPAS METHOD

Using the MCDM framework, we presented and verified a set of high - level parameters for assessing compressed aerial photographs. In order to estimate lossy compression techniques that are controlled by suitable quality parameters for data compression and graphically acceptable lossy compression, we have created a new MCDM issue. Additionally, we ranked lossy compression methods with various compression ratios according to how well they worked with various aerial image resolutions. We choose the Direct Weighted Determination and "Weighted Aggregate Product Assessment (WASPAS)" procedures in the neutrosopic environment to guarantee the stability of the MCDM ranking outcomes. When used to address diverse real-world issues, these approaches demonstrate excellent stability. We have created a novel multi-criteria decision-making process for choosing the best lossy compression for aerial photos, which also includes approaches for resolving other subtasks like adjusting weights or feature sets. There are five parts to the article. gives a summary of studies that have been published on evaluating the quality of compressed aerial images. specifies the direct weights and MCDM pythagorean fuzzy WASPAS methodologies for data processing, as well as the overall structure of the strategy, a set of alternatives, and conditions for the non - linear and non-task of evaluation criteria of loss decompression of aerial photographs. A selection of aerial photos is offered together with a quality evaluation, a ranking of the collection's summary results through using Neutrosopic WASPAS-SVNS method, or a presentation of the study. There are conclusions and recommendations for the future. The purpose of the current study is to suggest a strategy that combines the enhanced accuracy of non - linear and non-decision making with the resilience of interval-valued fuzzy numbers in handling uncertainty. In light of this, a proposed extension of the recently created "Weighted Aggregate Product Assessment (WASPAS)" is made. To obtain the best estimation accuracy, WASPAS employs a suggested strategy to optimise the weighted aggregate function. By choosing an appropriate location, it has been effectively applied to the sustainable and environment evaluation of modernising multiple residential homes. It is demonstrated in a case study how to rank the facades of public and commercial buildings, and the method's reliability is confirmed. crisp in order to improve rankings accuracy in a crucial situation, WASPAS was used to choose the optimum occupational safety approach during construction work.

This approach, known as WASPAS-IVIF in the current study, is expanded with intermission intuitionistic fuzzy numbers. A general version of fuzzy sets that takes into account both the ordinal membership degree and the non-membership degree of the fuzzy numbers are interval-valued intuitionistic fuzzy numbers. The experts were given a questionnaire to complete in order to determine the weight efficiency indices. SWARA-WASPAS was established in response to their input. With regard to SWARA evaluation, weighting criteria, and key supplier selection, WASPAS is utilised to assess various options. Since the "SWARA method" is correlated with the ability of trying to assess the conclusions or special interests about the great significance of qualities in the taken into account when designing (Kersuliene et al.., 2010), Aghdaie et al. (2013) asserted that the rationalisation there next to using this approach is to use the expertise and insights of experts. The first parameter in the ranking is thought to be the most significant, and the final parameter in the ranking is thought to be the least significant, according to experts who apply their own instincts. The SWARA approach is more appealing and effective for researchers due to the fact that it requires fewer comparison than other MCDM techniques, according to Stanujkic et al (2015).'s comparison of Contact with different with other MCDM methods like AHP, ANP, etc. The WASPAS method was proposed by Javadskas et al. (2012), who also showed in their analysis that WASPAS' accuracy is superior to both its robustness and other approaches. The "weighted sum method (WSM)" and the "weighted product method", two well-known MCDM techniques, are combined in this method (WPM). In their study, showed that utilising both WSM and WPM together produces results that are more accurate than using either system alone. Despite being relatively new tools, SWARA and WASPAS are developing a name for themselves in modern research.

4. RESULT AND DISCUSSION

TABLE 1. Sustainable Aviation

	TCI, MM$	OPEX, MM$	MFSP, $ L− 1	MFSP, $ Mg− 1
HEFA_SO	77.00000	54.00000	1.12000	1446.00000
HEFA_YG	69.00000	46.00000	0.88000	1190.00000
VB_Stover	398.00000	89.00000	2.32000	2610.00000
VB_Pine	425.00000	99.00000	2.54000	2796.00000
ATJ_Stover	417.00000	86.00000	2.31000	2793.00000
ATJ_Pine	435.00000	90.00000	2.42000	2862.00000
DSHC_Stover	654.00000	136.00000	3.61000	4689.00000

Table 1 shows the Sustainable Aviation using MOORA method. The alternatives are HEFA_SO, HEFA_YG, VB_Stover, VB_Pine, ATJ_Stover, ATJ_Pine, DSHC_Stover, DSHC_Pine, FP_Stover, FP_Pine, GFT_Stover and GFT_Pine. The evaluation parameters are TCI (MM$), OPEX (MM$), MFSP, ($ L− 1) and MFSP ($ Mg− 1) to calculate the final value.

Shows the figure 1 Sustainable Aviation using MOORA method. The alternatives are HEFA_SO, HEFA_YG, VB_Stover, VB_Pine, ATJ_Stover, ATJ_Pine, DSHC_Stover, DSHC_Pine, FP_Stover, FP_Pine, GFT_Stover and GFT_Pine. The evaluation parameters are TCI (MM$), OPEX (MM$), MFSP, ($ L− 1) and MFSP ($ Mg− 1) to calculate the final value.

TABLE 2. Performance value

	Performance value			
HEFA_SO	0.11374	0.36986	0.78571	0.82296
HEFA_YG	0.10192	0.31507	1.00000	1.00000
VB_Stover	0.58789	0.60959	0.37931	0.45594
VB_Pine	0.62777	0.67808	0.34646	0.42561
ATJ_Stover	0.61595	0.58904	0.38095	0.42607
ATJ_Pine	0.64254	0.61644	0.36364	0.41579
DSHC_Stover	0.96603	0.93151	0.24377	0.25379

Shows the table 2 Performance value is divided by the maximum of the given value

TABLE 3. Weight

	Weight			
HEFA_SO	0.25	0.25	0.25	0.25
HEFA_YG	0.25	0.25	0.25	0.25
VB_Stover	0.25	0.25	0.25	0.25
VB_Pine	0.25	0.25	0.25	0.25
ATJ_Stover	0.25	0.25	0.25	0.25
ATJ_Pine	0.25	0.25	0.25	0.25
DSHC_Stover	0.25	0.25	0.25	0.25

Table 3 shows the weight of the Sustainable Aviation the weight is equal for all the value in the set of data in the table 1. The weight is multiplied with the previous table to get the next value.

Table 4. Weighted normalized decision matrix (WSM) and Preference Score

	Weighted normalized decision matrix				Preference Score
HEFA_SO	0.02843	0.09247	0.19643	0.20574	0.52307
HEFA_YG	0.02548	0.07877	0.25000	0.25000	0.60425
VB_Stover	0.14697	0.15240	0.09483	0.11398	0.50818
VB_Pine	0.15694	0.16952	0.08661	0.10640	0.51948
ATJ_Stover	0.15399	0.14726	0.09524	0.10652	0.50300
ATJ_Pine	0.16064	0.15411	0.09091	0.10395	0.50960
DSHC_Stover	0.24151	0.23288	0.06094	0.06345	0.59877

Table 4 shows the weighted normalization decision matrix using weighted sum method it is calculated by multiplying the weight and performance value in table 2 and table 3. the preference score of WSM Weighted Sum Model it is calculated by the sum of the value on the row of weighted normalized decision matrix.

TABLE 6. Weighted normalized decision matrix (WPM) and Preference Score

	Weighted normalized decision matrix				Preference Score
HEFA_SO	0.58073	0.77985	0.94149	0.95246	0.40611
HEFA_YG	0.56502	0.74921	1.00000	1.00000	0.42332
VB_Stover	0.87564	0.88361	0.78478	0.82173	0.49895
VB_Pine	0.89012	0.90745	0.76721	0.80770	0.50054
ATJ_Stover	0.88590	0.87607	0.78563	0.80792	0.49262
ATJ_Pine	0.89531	0.88608	0.77655	0.80301	0.49469
DSHC_Stover	0.99140	0.98242	0.70266	0.70977	0.48574

Table 4 shows the weighted normalization decision matrix using weighted Product method it is calculated by multiplying the weight and performance value in table 2 and table 3. the preference score of WPM Weighted Product Model it is calculated by the product of the value on the row on weighted normalized decision matrix.

TABLE 7. WASPAS coefficient and Rank

	WASPAS Coefficient	Rank
HEFA_SO	0.46459	7
HEFA_YG	0.51378	2
VB_Stover	0.50357	4
VB_Pine	0.51001	3
ATJ_Stover	0.49781	6
ATJ_Pine	0.50215	5
DSHC_Stover	0.54226	1

Table 7 shows the WASPAS Coefficient value lambda 0.5 and sustainable aviation ranking values. The Weighted Aggregates Sum Product Assessment (WASPAS) method was used to evaluate various sustainable aviation fuel alternatives, resulting in different WASPAS coefficients for each option. The coefficients indicate the overall performance of each fuel alternative based on multiple criteria. According to the WASPAS results, the DSHC_Stover alternative had the highest coefficient of 0.54226, suggesting it is the most preferred option among those evaluated.

Following this, HEFA_YG achieved a coefficient of 0.51378, while VB_Pine and VB_Stover had coefficients of 0.51001 and 0.50357, respectively. Other alternatives, such as ATJ_Pine and ATJ_Stover, had slightly lower coefficients of 0.50215 and 0.49781, respectively. The lowest coefficient was for HEFA_SO, with a value of 0.46459. These results highlight the varying performance levels of different sustainable aviation fuels, with DSHC_Stover being the most favorable under the evaluation criteria used. DSHC_Stover is got first rank and HEFA_SO is got lowest rank

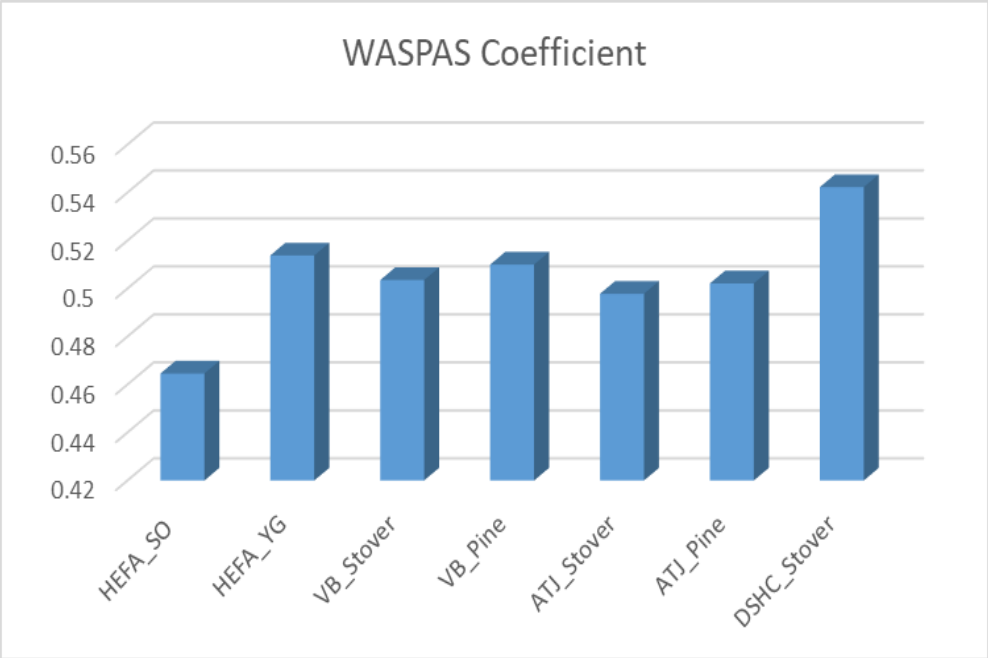


FIGURE 3. WASPAS Coefficient

The figure 3 WASPAS coefficient value DSHC_Stover the highest value and HEFA_SO is lowest value.

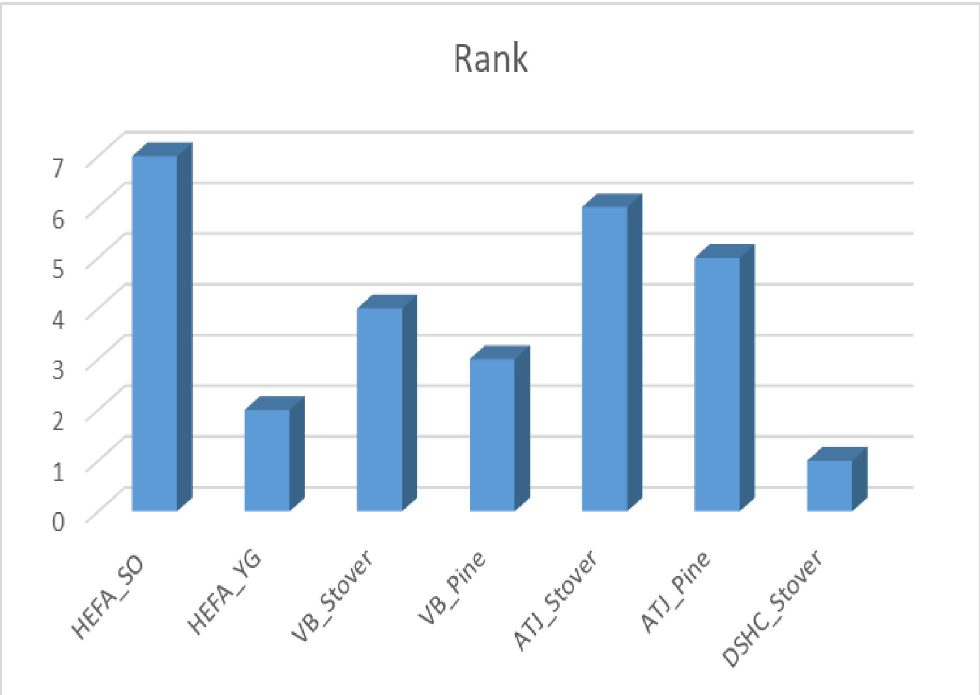


FIGURE 4. sustainable aviation rank

Shows the figure 4 sustainable aviation rank using WASPAS method. DSHC_Stover is got first rank and HEFA_SO is got lowest rank

5. CONCLUSION

This article discusses a number of intricate conclusions that came from a discourse of sustainable aviation policymaking. The procurement technology and managerial solutions, which carry far more weight than geographical factors, dominate ecological modernization in the hotly contentious sustainable aviation policy, which is a tumultuous mashup of competing discourses. the social facets of sustainability, for instance. While the focus of this essay, with some minor differences, is on sustainable alternative architecture in India, ecological modernization seems to be the major theme in other nations and locations. The methodology created in this study combines the course WASPAS and rough AHP approaches, with the latter being used to rank and evaluate vendors and the former to determine the weight values of criteria. The model was verified by choosing vendors within the business to make PVC furnishings depending on nine criteria. The fifth possibility is the best choice in both the sensitivity analysis areas of modifying the coefficient's value and solving the ensemble method using various methods recently created, according to the findings obtained using the approximation WASPAS methodology. The approximate WASPAS technique has a perfect connection with the ratings of the other approaches, according to analysis of the data from the determination of Spearman's correlation coefficient. sustainable aviation rank using WASPAS method. DSHC_Pine is got first rank and GFT_ Pine is got lowest rank

REFERENCE

[1]. Rice, Connor, Nadine K. Ragbir, Stephen Rice, and Gina Barcia. "Willingness to pay for sustainable aviation depends on ticket price, greenhouse gas reductions and gender." Technology in Society 60 (2020): 101224.

[2]. Gössling, Stefan, and Chris Lyle. "Transition policies for climatically sustainable aviation." Transport Reviews 41, no. 5 (2021): 643-658.

[3]. Walker, Simon, and Matthew Cook. "The contested concept of sustainable aviation." Sustainable Development 17, no. 6 (2009): 378-390.

[4]. T. Santhosh; Harshitha. T. N,; Sathiyaraj Chinnasamy; M. Ramachandran, “Adaptive Subgradient Methods for Leadership And Development”, Recent trends in Management and Commerce 4(2) 2023, 101-106.

[5]. Chiaramonti, David. "Sustainable aviation fuels: the challenge of decarbonization." Energy Procedia 158 (2019): 1202-1207.

[6]. 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).

[7]. Abrantes, Ivo, Ana F. Ferreira, André Silva, and Mário Costa. "Sustainable aviation fuels and imminent technologies-CO2 emissions evolution towards 2050." Journal of Cleaner Production 313 (2021): 127937.

[8]. Heyne, Joshua, Bastian Rauch, Patrick Le Clercq, and Meredith Colket. "Sustainable aviation fuel prescreening tools and procedures." Fuel 290 (2021): 120004.

[9]. Fuladipanah, Mehdi, H. Md Azamathulla, Kiran Tota-Maharaj, Vishwanadham Mandala, and Aaron Chadee. "Precise forecasting of scour depth downstream of flip bucket spillway through data-driven models." *Results in Engineering* 20 (2023): 101604.

[10]. Tanzil, Abid H., Kristin Brandt, Michael Wolcott, Xiao Zhang, and Manuel Garcia-Perez. "Strategic assessment of sustainable aviation fuel production technologies: Yield improvement and cost reduction opportunities." Biomass and Bioenergy 145 (2021): 105942.

[11]. Amaeshi, Kenneth M., and Andrew Crane. "Stakeholder engagement: a mechanism for sustainable aviation." Corporate social responsibility and environmental management 13, no. 5 (2006): 245-260.

[12]. Gössling, Stefan. "Risks, resilience, and pathways to sustainable aviation: A COVID-19 perspective." Journal of Air Transport Management 89 (2020): 101933.

[13]. Ranasinghe, Kavindu, Kai Guan, Alessandro Gardi, and Roberto Sabatini. "Review of advanced low-emission technologies for sustainable aviation." Energy 188 (2019): 115945.

[14]. Bawa, Surjit Singh. "Implement gamification to improve enterprise performance." *International Journal of Intelligent Systems and Applications in Engineering* 11, no. 2 (2023): 784-788.

[15]. Capaz, Rafael S., Elisa Guida, Joaquim EA Seabra, Patricia Osseweijer, and John A. Posada. "Mitigating carbon emissions through sustainable aviation fuels: costs and potential." Biofuels, Bioproducts and Biorefining 15, no. 2 (2021): 502-524.

[16]. TR, Praveenkumar. "Lowest emission sustainable aviation biofuels as the potential replacement for the Jet-A fuels." Aircraft Engineering and Aerospace Technology 93, no. 3 (2021): 502-507.

[17]. Chinnasami Sivaji, Prabakaran Nanjundan, M. Ramachandran, Jaganathan Rajamanickam, "Effects of Nutrition Package Claims, Nutrition Facts Panels, And Motivation to Process Nutrition Information on Consumer Product Evaluations Using the WPM Method", Journal on Materials and its Characterization 2(3), September, 2023, 28-35.

[18]. Herath, Madhawa, Tharaka Jayathilaka, Hazi Mohammad Azamathulla, Vishwanadham Mandala, Namal Rathnayake, and Upaka Rathnayake. "Sensitivity analysis of parameters affecting wetland water levels: A study of flood detention basin, Colombo, Sri Lanka." *Sensors* 23, no. 7 (2023): 3680.

[19]. 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).

[20]. Ng, Kok Siew, Danial Farooq, and Aidong Yang. "Global biorenewable development strategies for sustainable aviation fuel production." Renewable and Sustainable Energy Reviews 150 (2021): 111502.

[21]. 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.

[22]. Zhao, Xin, Farzad Taheripour, Robert Malina, Mark D. Staples, and Wallace E. Tyner. "Estimating induced land use change emissions for sustainable aviation biofuel pathways." Science of the Total Environment 779 (2021): 146238.

[23]. Ahmad, Salman, Jamal Ouenniche, Ben W. Kolosz, Philip Greening, John M. Andresen, M. Mercedes Maroto-Valer, and Bing Xu. "A stakeholders’ participatory approach to multi-criteria assessment of sustainable aviation fuels production pathways." International Journal of Production Economics 238 (2021): 108156.

[24]. Bawa, Surjit Singh. "Implementing Text Analytics with Enterprise Resource Planning." *International Journal of Simulation--Systems, Science & Technology* 24, no. 1 (2023).

[25]. Ilbahar, Esra, and Cengiz Kahraman. "Retail store performance measurement using a novel interval-valued Pythagorean fuzzy WASPAS method." Journal of Intelligent & Fuzzy Systems 35, no. 3 (2018): 3835-3846.

[26]. Ayyildiz, Ertugrul, Melike Erdogan, and Alev Taskin Gumus. "A Pythagorean fuzzy number-based integration of AHP and WASPAS methods for refugee camp location selection problem: a real case study for Istanbul, Turkey." Neural Computing and Applications 33, no. 22 (2021): 15751-15768.

[27]. Fuladipanah, Mehdi, H. Md Azamathulla, Ozgur Kisi, Mehdi Kouhdaragh, and Vishwandham Mandala. "Quantitative forecasting of bed sediment load in river engineering: an investigation into machine learning methodologies for complex phenomena." *Water Supply* 24, no. 2 (2024): 585-600.

[28]. Ali, Jawad, Zia Bashir, and Tabasam Rashid. "WASPAS-based decision making methodology with unknown weight information under uncertain evaluations." Expert Systems with Applications 168 (2021): 114143.

[29]. Bausys, Romualdas, and Giruta Kazakeviciute-Januskeviciene. "Qualitative rating of lossy compression for aerial imagery by neutrosophic WASPAS method." Symmetry 13, no. 2 (2021): 273.

[30]. Ponnada, Venkata Tulasiramu, and SV Naga Srinivasu. "Efficient CNN for lung cancer detection." *Int J Recent Technol Eng* 8, no. 2 (2019): 3499-505.

[31]. Manjula Selvam, M. Ramachandra, Chandrasekar Raja, Chinnasami Sivaji, "Phosphatenes as Building Blocks for The Synthesis of Triphosphate Heterocycles Using the EDAS Method", Journal on Materials and its Characterization 2(3), September, 2023, 18-27.

[32]. Bawa, Surjit Singh. "How Business can use ERP and AI to become Intelligent Enterprise." *vol* 8 (2023): 8-11.

[33]. Zavadskas, Edmundas Kazimieras, Jurgita Antucheviciene, Seyed Hossein Razavi Hajiagha, and Shide Sadat Hashemi. "Extension of weighted aggregated sum product assessment with interval-valued intuitionistic fuzzy numbers (WASPAS-IVIF)." Applied soft computing 24 (2014): 1013-1021.

[34]. Palanimuthu, Kogila, Eshetu Fikadu Hamba Yigazu, Gemechu Gelalcha, Yirgalem Bekele, Getachew Birhanu, and Birhanu Gutu. "Assessment of stress, fear, anxiety and depression on COVID-19 outbreak among adults in South-Western Ethiopia." *Prof.(Dr) RK Sharma* 21, no. 1 (2021): 440.

[35]. Baušys, Romualdas, and Birutė Juodagalvienė. "Garage location selection for residential house by WASPAS-SVNS method." Journal of civil engineering and management 23, no. 3 (2017): 421-429.

[36]. Singh, Rohit Kumar, and Sachin Modgil. "Supplier selection using SWARA and WASPAS–a case study of Indian cement industry." Measuring Business Excellence (2020).

[37]. Akshaya, V., Vishwanadham Mandala, Chunduru Anilkumar, P. VishnuRaja, and R. Aarthi. "Security enhancement and attack detection using optimized hybrid deep learning and improved encryption algorithm over Internet of Things." *Measurement: Sensors* 30 (2023): 100917.

[38]. Ponnada, Venkata Tulasiramu, and SV Naga Srinivasu. "Integrated clinician decision supporting system for pneumonia and lung cancer detection." *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* (2019).

[39]. Zavadskas, Edmundas Kazimieras, Darius Kalibatas, and D. Kalibatiene. "A multi-attribute assessment using WASPAS for choosing an optimal indoor environment." Archives of Civil and Mechanical Engineering 16 (2016): 76-85.

[40]. Rani, Pratibha, Arunodaya Raj Mishra, and Kamal Raj Pardasani. "A novel WASPAS approach for multi-criteria physician selection problem with intuitionistic fuzzy type-2 sets." Soft Computing 24 (2020): 2355-2367.

[41]. Bawa, Surjit Singh. "Automate Enterprise Resource Planning with Bots."

[42]. Chinnasami Sivaji, Prabakaran Nanjundan, M. Ramachandran, Jaganathan Rajamanickam," Future Research Opportunities Agricultural Sector Using Weighted sum method (WSM)", Computer Science, Engineering and Technology, 1(3), 2023, 30-38.

[43]. Otay, Irem, Cengiz Kahraman, Başar Öztayşi, and Sezi Çevik Onar. "A novel single-valued spherical fuzzy AHP-WASPAS methodology." In Developments of Artificial Intelligence Technologies in Computation and Robotics: Proceedings of the 14th International FLINS Conference (FLINS 2020), pp. 190-198. 2020.

[44]. Bawa, Surjit Singh. "How Business can use ERP and AI to become Intelligent Enterprise." *vol* 8 (2023): 8-11.

[45]. Keshavarz Ghorabaee, Mehdi, Maghsoud Amiri, Edmundas Kazimieras Zavadskas, and Jurgita Antuchevičienė. "Assessment of third-party logistics providers using a CRITIC–WASPAS approach with interval type-2 fuzzy sets." Transport 32, no. 1 (2017): 66-78.

[46]. Ponnada, Venkata Tulasiramu, and SV Naga Srinivasu. "End to End System for Pneumonia and Lung Cancer Detection using Deep Learning." *Int. J. Eng. Adv. Technol* 8 (2019).

[47]. Mandala, Vishwanadham, MA Reetha Jeyarani, A. Kousalya, M. Pavithra, and M. Arumugam. "An Innovative Development with Multidisciplinary Perspective in Metaverse Integrating with Blockchain Technology with Cloud Computing Techniques." In *2023 International Conference on Inventive Computation Technologies (ICICT)*, pp. 1182-1187. IEEE, 2023.

[48]. Stojić, Gordan, Željko Stević, Jurgita Antuchevičienė, Dragan Pamučar, and Marko Vasiljević. "A novel rough WASPAS approach for supplier selection in a company manufacturing PVC carpentry products." Information 9, no. 5 (2018): 121.

[49]. Keshavarz-Ghorabaee, Mehdi, Maghsoud Amiri, Mohammad Hashemi-Tabatabaei, Edmundas Kazimieras Zavadskas, and Arturas Kaklauskas. "A new decision-making approach based on Fermatean fuzzy sets and WASPAS for green construction supplier evaluation." Mathematics 8, no. 12 (2020): 2202.

[50]. Gutu, Birhanu, Genene Legese, Nigussie Fikadu, Birhanu Kumela, Firafan Shuma, Wakgari Mosisa, Zelalem Regassa et al. "Assessment of preventive behavior and associated factors towards COVID-19 in Qellam Wallaga Zone, Oromia, Ethiopia: A community-based cross-sectional study." *PloS one* 16, no. 4 (2021): e0251062.

[51]. Ramya Sharma, M. Ramachandran, Vimala Saravanan, Chandrasekar Raja, "A Descriptive and Historical Study of Bibliography with Applications to Medical Science Using WASPAS Method", Journal on Innovations in Teaching and Learning, 2(3), September 2023, 30-37.

[52]. Ponnada, Venkata Tulasiramu, and S. V. Naga Srinivasu. "Edge AI system for pneumonia and lung cancer detection." *Int J Innov Technol Exploring Eng* 8, no. 9 (2019).

[53]. Bawa, Surjit Singh. "Enhancing Usability and User Experience in Enterprise Resource Planning Implementations."

[54]. Mandala, Vishwanadham, R. Rajavarman, C. Jamunadevi, R. Janani, and T. Avudaiappan. "Recognition of E-Commerce through Big Data Classification and Data Mining Techniques Involving Artificial Intelligence." In *2023 8th International Conference on Communication and Electronics Systems (ICCES)*, pp. 720-727. IEEE, 2023.