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Assessing Bioresource Suitability for Pyrolysis Applications Using the EDAS Multi-Criteria Decision Analysis Method

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ABSTRACT

The selection of appropriate raw materials is crucial for improving the efficiency and cost- effectiveness of pyrolysis processes. In this study, we utilized the Evaluation based on Distance from Average Solution (EDAS) method, a multi-criteria decision-making approach, to comprehensively evaluate the suitability of different biomass sources for pyrolysis. We examined five specific bioresources—sunflower shells, hardwood, wheat straw, sugarcane bagasse, and corn cobs—based on key criteria: cellulose, hemicellulose, volatile matter, moisture content, and ash content. Utilizing the EDAS technique involved constructing a decision matrix, computing positive and negative distance metrics from the average solution, and ultimately determining a final evaluation score (ASi) for each bioresource. The analysis unveiled hardwood as the most preferable feedstock, achieving the highest ASi of 0.93866, closely followed by sugarcane bagasse with an ASi of 0.93765. These bioresources showcased superior performance across numerous criteria, including elevated cellulose and volatile matter contents, coupled with low moisture and ash levels. Sunflower shells and corn cobs secured the third and fourth positions, respectively, displaying moderate positive deviations from the average solution. Conversely, wheat straw ranked at the bottom, registering an ASi of 0.00000, indicative of its limited suitability as a pyrolysis feedstock due to its high moisture content and relatively low volatile matter content. The EDAS method&39;s capability to account for both positive and negative deviations from the average solution enabled a balanced evaluation, revealing the strengths and weaknesses of each biomass source. This methodology facilitated a deeper understanding of the trade-offs involved, aiding decision-making in selecting suitable feedstocks tailored to specific process needs and desired product attributes. The research highlighted the effectiveness of the EDAS method in assessing material selection for pyrolysis, offering a structured and transparent approach to tackling complex multi-criteria decision- making challenges. By incorporating relevant factors and capitalizing on the method&39;s simplicity and computational efficiency, researchers and industry experts can make well-informed choices to optimize pyrolysis processes and advance the sustainable conversion of biomass resources into valuable products.

1. INTRODUCTION

Pyrolysis, a thermochemical decomposition method occurring in the absence of oxygen, has attracted considerable interest as a viable waste-to-energy conversion technique. This process involves exposing different organic materials like biomass, plastics, and municipal solid waste to high temperatures, resulting in the production of valuable outputs such as bio-oils, gases, and solid residues known as chars. The suitability of a material for pyrolysis is contingent upon several factors, including its composition, physical properties, and thermal behavior. Biomass feedstocks, such as agricultural residues,

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forestry wastes, and energy crops, have been extensively studied due to their abundance and renewable nature. However, their inherent heterogeneity and varying compositions necessitate careful evaluation to optimize the pyrolysis process and product yields [1]. Conversely, plastics, which are predominantly derived from fossil resources, offer a distinct set of advantages and challenges. Their high calorific values and consistent compositions make them attractive feedstocks, but their potential environmental impacts and the presence of additives and contaminants require meticulous consideration [2]. The evaluation of material selection for pyrolysis often entails thorough characterization techniques to understand the properties of the feedstock [3]. Proximate and ultimate analyses offer insights into the relative proportions of moisture, volatile matter, fixed carbon, and ash content, as well as the elemental composition [3]. Thermal analysis techniques such as thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) provide valuable information about the thermal degradation behavior, kinetics, and energy requirements during pyrolysis [4]. Additionally, spectroscopic techniques like Fourier-transform infrared (FTIR) spectroscopy and nuclear magnetic resonance (NMR) spectroscopy aid in elucidating the chemical structure and functional groups present in the feedstock [5].The inclusion of inorganic components, like alkali and alkaline earth metals, can markedly impact both the pyrolysis procedure and the quality of the resulting products. These elements may serve as catalysts, stimulating particular reactions or modifying the distribution of products [6]. Conversely, certain inorganic substances might lead to the creation of undesirable compounds or facilitate problems like agglomeration and fouling throughout the process [7]. Thus, evaluating the inorganic makeup of the feedstock is essential for fine-tuning pyrolysis conditions and addressing potential operational hurdles. In recent times, there has been an increasing focus on investigating the co-pyrolysis of various feedstock materials, capitalizing on their unique characteristics and the synergies they offer. One example involves studying the simultaneous pyrolysis of biomass and plastics, aiming to enhance energy recovery and maximize the value of renewable and non-renewable resources [8]. Likewise, researchers have looked into co-pyrolysis of coal and biomass to improve product quality and address environmental issues linked with coal usage [9]. The evaluation of material selection for pyrolysis has expanded to include the exploration of utilizing waste streams, in line with the principles of the circular economy and sustainable waste management. Municipal solid waste (MSW), characterized by a diverse mix of organic and inorganic components, has received considerable attention as a pyrolysis feedstock [10]. Likewise, there's been notable interest in pyrolyzing agricultural residues like rice husk, sugarcane bagasse, and wheat straw, given their widespread availability and potential for energy retrieval [11].Moreover, the evaluation of material selection for pyrolysis has been shaped by the rising need for sustainable and eco-friendly approaches. The adoption of renewable and carbon-neutral feedstocks, such as lignocellulosic biomass, has become increasingly popular for its potential to curb greenhouse gas emissions and lessen reliance on fossil fuels [12]. Furthermore, researchers have investigated the combination of pyrolysis with other conversion methods like gasification and catalytic upgrading to improve overall process efficiency and the quality of products [13]. The evaluation of material selection for pyrolysis has additionally been impacted by the imperative to tackle environmental issues and adhere to regulatory standards. Certain feedstocks may contain hazardous substances like heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs), presenting substantial challenges that require suitable pretreatment or mitigation approaches [14]. Consequently, there's been a critical focus on developing analytical techniques for precisely characterizing and quantifying these contaminants, which has become integral to the evaluation of feedstocks. Moreover, the economic viability of pyrolysis processes is closely tied to the availability, cost, and logistics associated with the feedstock supply chain. The assessment of pyrolysis material selection often involves techno-economic analyses and life cycle assessments to evaluate the long-term sustainability and profitability of using specific feedstocks [15]. These assessments consider factors such as transportation costs, feedstock pretreatment requirements, and the potential for revenue generation from the pyrolysis products. Progress in computational modeling and simulation techniques has further enhanced the evaluation of material selection for pyrolysis. Methods like distributed activation energy models (DAEM) and computational fluid dynamics (CFD) simulations have been utilized to forecast the pyrolysis characteristics of different feedstocks and fine-tune process variables [16]. These tools play a vital role in comprehending the intricate interplay among feedstock attributes, reaction kinetics, and operational conditions, thereby assisting in the development and refinement of pyrolysis systems. In the future, the evaluation of pyrolysis material selection is poised to be shaped by evolving trends in the biorefinery and circular economy domains. As pyrolysis becomes integrated with other conversion methods like catalytic upgrading, hydroprocessing, and gasification, there will likely be a need to assess novel feedstock combinations and address compatibility concerns [17]. Moreover, the growing emphasis on extracting value from waste streams and by-products across diverse industries such as food processing, pulp and paper, and textile manufacturing could lead to the exploration of alternative pyrolysis feedstocks.

2. METHODOLOGY

The Evaluation based on Distance from Average Solution (EDAS) is a modern multi-criteria decision-making (MCDM) technique introduced by Keshavarz Ghorabaee et al. in 2015. It has garnered attention in recent times for its straightforwardness, effectiveness, and capability to address intricate decision-making challenges involving numerous conflicting criteria. The EDAS method is designed to assess alternatives by measuring their distances from the average solution, thereby offering a ranking that accounts for both the favorable and unfavorable attributes of each alternative. The EDAS method starts by creating a decision matrix, where the rows depict the alternatives, and the columns represent the evaluation criteria. Each cell in the matrix reflects an alternative's performance concerning a specific criterion. Subsequently, the method calculates the average solution by computing the mean of all alternatives for each criterion [18]. Next, two distance measures are computed for each alternative: the positive distance from the average (PDA) and the negative distance from the average (NDA). The PDA sums up the weighted distances between the alternative and the average solution for the criteria where the alternative surpasses the average. Conversely, the NDA sums up the weighted distances between the alternative and the average solution for the criteria where the alternative falls short of the average [19]. The PDA-to-NDA ratio is then computed for each alternative, offering a gauge of its relative desirability. Alternatives with higher PDA/NDA ratios are deemed more desirable, indicating a greater positive distance from the average solution compared to their negative distance [20].Following this, alternatives are ranked in descending order based on their PDA/NDA ratios, with the alternative possessing the highest ratio being the preferred choice. If multiple alternatives share the same PDA/NDA ratio, additional criteria or decision-maker preferences can be invoked to resolve ties. A notable advantage of the EDAS method lies in its capability to handle both beneficial (maximization) and non-beneficial (minimization) criteria without necessitating normalization or transformation of the decision matrix. This streamlines the calculation process and diminishes the potential for errors or distortions inherent in normalization techniques [21]. The efficacy of the EDAS method has been demonstrated across various decision-making scenarios in diverse domains, including renewable energy planning [22], supplier selection [23], material selection [24], and sustainable manufacturing [25]. Comparative studies with other MCDM methods such as TOPSIS, VIKOR, and COPRAS have showcased EDAS's comparable or superior performance in terms of ranking accuracy and consistency [26]. Despite its advantages, the EDAS method is not without limitations. Like other MCDM methods, it relies on the accurate determination of criteria weights, which can be subjective and influenced by decision-maker preferences. Additionally, the EDAS method does not explicitly consider potential interactions or dependencies among the evaluation criteria, which may be relevant in certain decision-making scenarios [27]. In response to these constraints, researchers have put forth several extensions and adaptations to enhance the EDAS method. One approach involves the development of Integrated EDAS methods, which amalgamate EDAS with other methodologies like fuzzy logic [28], rough sets [29], and interval-valued intuitionistic fuzzy sets [30], to manage uncertainty and imprecision inherent in decision-making processes.Bioresources play a crucial role across industries, serving as renewable reservoirs for energy, materials, and chemicals. Among these resources, sunflower shells, hardwood, wheat straw, sugarcane bagasse, and corn cobs stand out due to their unique compositions and potential applications. Evaluating these bioresources based on key parameters like cellulose, hemicellulose, volatile matter, moisture content, and ash content illuminates their suitability for diverse purposes. Sunflower shells, originating from sunflower seed processing, contain notable cellulose content, making them desirable for cellulose-centric industries such as paper and textiles. Despite this, they possess comparatively lower levels of hemicellulose compared to other biomass sources, restricting their potential in hemicellulose-derived products. With a moderate volatile matter content, sunflower shells are suitable for energy generation via combustion. However, their elevated ash content presents challenges in combustion processes, necessitating effective ash management strategies. Hardwood, sourced from deciduous trees like oak and maple, boasts high levels of cellulose and hemicellulose, making it well-suited for a broad range of applications. Its low moisture content ensures efficient utilization in processes requiring dry biomass, such as biofuel production and wood-based composites. Furthermore, the relatively low ash content of hardwood minimizes issues related to ash during combustion, increasing its attractiveness for energy generation. Wheat straw, a residue from wheat harvesting, presents a balanced composition of cellulose and hemicellulose, suitable for various biorefinery processes. With a moderate volatile matter content, wheat straw can be efficiently converted into biofuels like bioethanol and biogas. However, its higher moisture content compared to woody biomass necessitates appropriate drying techniques for optimal utilization. Additionally, managing its ash content is crucial to address operational challenges in combustion-based applications. Sugarcane bagasse, a byproduct of sugarcane processing, contains significant amounts of cellulose and hemicellulose, making it a valuable feedstock for bioenergy and biochemical production. Its low moisture content facilitates efficient handling and conversion processes, improving overall process economics. Sugarcane bagasse's moderate volatile matter content supports its utilization in thermal conversion technologies such as gasification. Nonetheless, its ash content can impact combustion efficiency, requiring ash removal mechanisms for sustained operation. Corn cobs, leftover husks from corn harvesting, feature a cellulose-rich composition, suitable for cellulose-derived products and biofuel production. Their moderate hemicellulose content complements cellulose in biorefinery processes, enhancing product yields. However, the relatively high moisture content of corn cobs necessitates drying for optimal utilization in energy and material applications. Additionally, effective management of their ash content is vital to minimize operational challenges and ensure efficient combustion. Each of these bioresources offers distinct advantages based on their compositions and properties. Sunflower shells, hardwood, wheat straw, sugarcane bagasse, and corn cobs can significantly contribute to the transition towards a more sustainable and resource-efficient economy, provided their attributes are carefully considered across various applications. Understanding the specific characteristics of these bioresources is essential for maximizing their potential and promoting their widespread adoption across diverse industries.

3. ANALYSIS AND DISCUSSION

TABLE 1. Bioresource Suitability for Pyrolysis Applications

Bioresource	Cellulose	Hemicellulose	Volatile Matter	Moisture Content	Ash Content
Sunflower shell	47.30	33.50	72.60	3.61	4.11
Hard wood	46.40	23.90	78.10	3.71	2.31
Wheat straw	35.90	21.40	57.70	16.21	4.21
Sugarcane bagasse	37.90	46.50	79.10	5.51	3.21
Corn cob	51.40	31.40	77.29	12.88	2.41
AVj	43.78000	31.34000	72.95800	8.38400	3.25000

Table 1 illustrates the composition of various bioresources regarding cellulose, hemicellulose, volatile matter, moisture content, and ash content, crucial components that define biomass. Cellulose and hemicellulose represent fundamental polysaccharide structures forming plant cell walls. The data reveals that sunflower shells boast the highest cellulose content at 47.30%, closely followed by corn cobs at 51.40%. This suggests their potential as valuable sources for cellulose extraction, utilized across diverse industries including paper manufacturing and biofuel production. Regarding hemicellulose content, sugarcane bagasse emerges with the highest value at 46.50%, trailed by corn cob at 31.40%. Hemicellulose plays a pivotal role in industrial processes such as ethanol production and biochemical synthesis. Volatile matter content denotes the combustible elements within biomass. Wheat straw exhibits the lowest volatile matter content at 57.70%, indicating its suitability as a feedstock for thermal applications like combustion or gasification. Moisture and ash content are equally vital considerations in biomass utilization. Elevated moisture content escalates transportation expenses and diminishes the energy efficiency of conversion processes. Among the listed bioresources, wheat straw records the highest moisture content at 16.21%, while sunflower shells exhibit the lowest at 3.61%. Lower ash content is preferable as high levels can induce equipment corrosion and slag formation during combustion. Corn cobs feature the lowest ash content at 2.41%, indicating their potential advantage in energy production contexts.

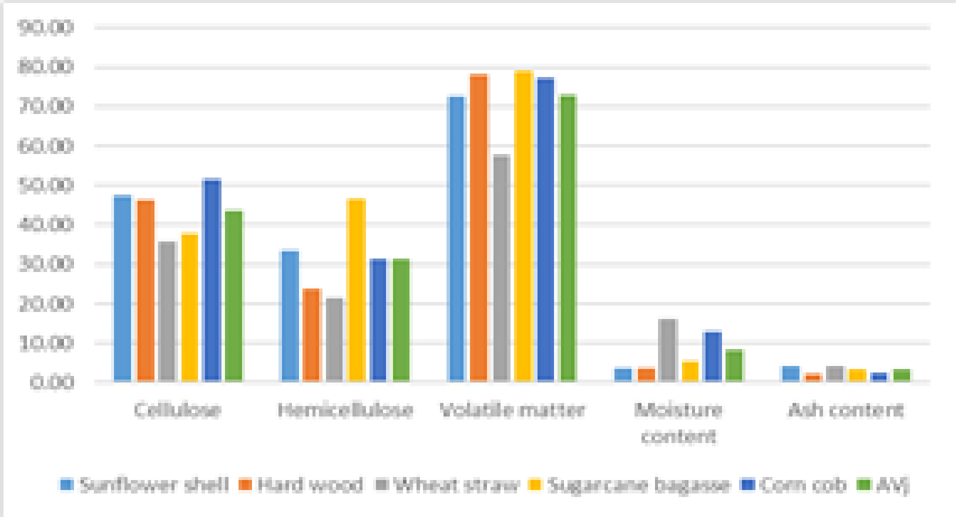

FIGURE 1. Bioresource Suitability for Pyrolysis

Figure 1 depicts the composition of various bioresources in terms of cellulose, hemicellulose, volatile matter, moisture content, and ash content, essential components defining biomass. Cellulose and hemicellulose are fundamental polysaccharide structures composing plant cell walls. The analysis indicates that sunflower shells showcase the highest cellulose content, closely trailed by corn cobs. This implies their potential as valuable sources for cellulose extraction, utilized across a spectrum of industries including paper manufacturing and biofuel production. In terms of hemicellulose content, sugarcane bagasse emerges with the highest value, followed by corn cob. Hemicellulose plays a critical role in industrial processes such as ethanol production and biochemical synthesis. Volatile matter content signifies the combustible elements within biomass. Wheat straw demonstrates the lowest volatile matter content, suggesting its suitability for thermal applications like combustion or gasification. Moisture and ash content are equally crucial factors in biomass utilization. Elevated moisture content increases transportation expenses and decreases the energy efficiency of conversion processes. Among the listed bioresources, wheat straw records the highest moisture content, while sunflower shells exhibit the lowest. Lower ash content is preferable as high levels can lead to equipment corrosion and slag formation during combustion. Corn cobs feature the lowest ash content, indicating their potential advantage in energy production contexts.

TABLE 2. Positive Distance from Average (PDA)

C1	C2	C3	C4	C5
0.0804	0.0689	0.0000	0.5694	0.0000
0.0598	0.0000	0.0705	0.5575	0.2892
0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.4837	0.0842	0.3428	0.0123
0.1741	0.0019	0.0594	0.0000	0.2585

Table 2 illustrates the Positive Distance from Average (PDA) metrics derived from the EDAS technique, assessing various bioresources across cellulose, hemicellulose, volatile matter, moisture content, and ash content. PDA values signify how each bioresource positively deviates from the average value within its respective category. Sunflower shells demonstrate above-average values in cellulose, hemicellulose, and moisture content categories, indicating their superiority in these aspects. However, their volatile matter and ash content fall within average ranges. Hardwood showcases above-average values in cellulose, volatile matter, moisture content, and ash content, hinting at its versatility across different applications. Wheat straw records a PDA value of zero across all categories, indicating its close alignment with average values and minimal deviations. Sugarcane bagasse exhibits above-average values in hemicellulose and volatile matter, highlighting its potential for applications requiring these attributes. However, its cellulose, moisture content, and ash content remain average. Corn cobs present above-average values in cellulose, volatile matter, and ash content, suggesting their potential for applications prioritizing these characteristics. However, their hemicellulose and moisture content are average.

TABLE 3. Negative Distance from Average (NDA)

0.00000	0.00000	0.00491	0.00000	0.26462
0.00000	0.23740	0.00000	0.00000	0.00000
0.17999	0.31717	0.20913	0.93344	0.29538
0.13431	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.53626	0.00000

Table 3 illustrates the Negative Distance from Average (NDA) metrics derived from the EDAS method for various bioresources across cellulose, hemicellulose, volatile matter, moisture content, and ash content. NDA values signify how each bioresource negatively deviates from the average value within its respective category. Sunflower shells showcase NDA values in the volatile matter and ash content categories, indicating their below-average performance in these aspects. However, they demonstrate no deviation from the average in terms of cellulose, hemicellulose, and moisture content. Hardwood exhibits below-average values solely in hemicellulose, indicating its diminished content compared to the average. It shows no deviation from average in other categories. Wheat straw manifests negative deviations from average across all categories except for volatile matter. This suggests its performance falls below average in cellulose, hemicellulose, moisture content, and ash content, particularly notable in moisture content. Sugarcane bagasse presents NDA values in the cellulose category, indicating its inferior performance compared to the average. However, it displays no deviation from average in other categories. Corn cobs demonstrate no negative deviations from average except in moisture content, suggesting below-average performance in this aspect while maintaining average values in other categories.

TABLE 4. Weights Distributed

C1	C2	C3	C4	C5
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20

Table 4 outlines the allocation of weights to various components among different bioresources, encompassing cellulose, hemicellulose, volatile matter, moisture content, and ash content. Each bioresource is assigned an equal weight of 0.2 for every component, indicating an equitable consideration of these parameters. Sunflower shells, hardwood, wheat straw, sugarcane bagasse, and corn cobs all receive uniform weight distributions, emphasizing a standardized method for assessing their composition. This equitable weighting approach implies that no single component holds precedence over others in the evaluation process. Through the even distribution of weights across all components, the analysis strives for a comprehensive appraisal of each bioresource's attributes. This methodology fosters an impartial comparison among different materials, fostering a holistic comprehension of their potential applications across various industries.

TABLE 5. Weighted PDA and SPi

Weighted PDA					SPi
0.01608	0.01378	0.00000	0.11388	0.00000	0.14375
0.01197	0.00000	0.01410	0.11150	0.05785	0.19541
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.09675	0.01684	0.06856	0.00246	0.18460
0.03481	0.00038	0.01188	0.00000	0.05169	0.09876

Table 5 showcases the accumulated positive deviations from the average (PDA) for all alternatives utilizing the EDAS method. This parameter, identified as SPi, encapsulates the combined positive variances of each bioresource across cellulose, hemicellulose, volatile matter, moisture content, and ash content, factored by their respective significance. Sunflower shells present an SPi value of 0.143748291, indicating a noteworthy positive deviation from the average solution across multiple components. Hardwood closely follows with an SPi of 0.195408962, suggesting substantial positive deviations likewise. Conversely, wheat straw records an SPi of 0, suggesting its alignment with the average solution, devoid of significant positive variances. Sugarcane bagasse and corn cobs display SPi values of 0.184603156 and 0.098760946, respectively, reflecting moderate positive deviations from the average solution.

TABLE 6. Weighted NDA and SNi

Weighted NDA					SNi
0.00000	0.00000	0.00098	0.00000	0.05292	0.05390
0.00000	0.04748	0.00000	0.00000	0.00000	0.04748
0.03600	0.06343	0.04183	0.18669	0.05908	0.38702
0.02686	0.00000	0.00000	0.00000	0.00000	0.02686
0.00000	0.00000	0.00000	0.10725	0.00000	0.10725

Table 6 depicts the weighted sum of the negative distance from the average (NDA) for all alternatives using the EDAS method. This measure, referred to as SNi, encapsulates the combined negative discrepancies of each bioresource across cellulose, hemicellulose, volatile matter, moisture content, and ash content, weighted based on their respective importance. Sunflower shells exhibit an SNi value of 0.053904463, indicating a slight negative deviation from the average solution, mainly driven by ash content. Hardwood follows closely with an SNi of 0.04747926, indicating minor negative deviations, particularly in hemicellulose content. In contrast, wheat straw shows a higher SNi value of 0.387024144, suggesting more significant negative deviations, notably in cellulose, hemicellulose, moisture content, and ash content. Sugarcane bagasse and corn cobs display SNi values of 0.026861581 and 0.107251908, respectively, indicating moderate negative deviations from the average solution.

TABLE 7. Normalized weighted

Bioresource	**NSP$_i$**	**NSN$_i$**
Sunflower shell	0.73563	0.86072
Hard wood	1.00000	0.87732
Wheat straw	0.00000	0.00000
Sugarcane bagasse	0.94470	0.93059
Corn cob	0.50541	0.72288

Table 7 displays the normalized weighted sum of positive (NSPi) and negative (NSNi) deviations from the average solution for all alternatives, offering a comprehensive assessment of each bioresource's performance relative to the average solution. These metrics consider both positive and negative deviations, providing a holistic perspective. Sunflower shells show an NSPi of 0.73563 and an NSNi of 0.86072, indicating a substantial positive deviation but also a notable negative deviation from the average solution, suggesting a mixed performance across different components. Hardwood exhibits an NSPi of 1.00000, indicating perfect alignment with positive deviations from the average solution, while its NSNi of 0.87732 suggests a minor negative deviation. Wheat straw records an NSPi and NSNi of 0.00000, signifying no significant positive or negative deviations from the average solution, indicating close alignment with average performance across all components. Sugarcane bagasse displays an NSPi of 0.94470 and an NSNi of 0.93059, showing a strong positive deviation but also a notable negative deviation from the average solution. Corn cobs present an NSPi of 0.50541 and an NSNi of 0.72288, indicating a moderate positive deviation but a relatively stronger negative deviation from the average solution compared to other alternatives.

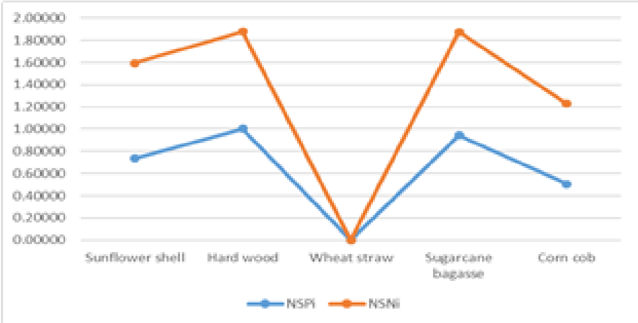

FIGURE 2. Normalized weighted

Figure 2 illustrates the normalized weighted sum of positive (NSPi) and negative (NSNi) deviations from the average solution for all alternatives, providing a comprehensive evaluation of each bioresource's performance relative to the average solution. These metrics incorporate both positive and negative discrepancies, offering a well-rounded assessment. Sunflower shells demonstrate an NSPi of 0.73563 and an NSNi of 0.86072, indicating a significant positive deviation but also a noticeable negative deviation from the average solution, suggesting varied performance across different components. Hardwood displays an NSPi of 1.00000, signifying perfect alignment with positive deviations from the average solution, while its NSNi of 0.87732 suggests a minor negative deviation. Wheat straw registers an NSPi and NSNi of 0.00000, indicating negligible positive or negative deviations from the average solution, indicating close conformity to average performance across all components. Sugarcane bagasse exhibits an NSPi of 0.94470 and an NSNi of 0.93059, showcasing a substantial positive deviation but also a significant negative deviation from the average solution. Corn cobs present an NSPi of 0.50541 and an NSNi of 0.72288, indicating a moderate positive deviation but a relatively more pronounced negative deviation from the average solution compared to other alternatives.

TABLE 8. Bioresource Ranking based on ASi

Bioresource	ASi	Rank
Sunflower shell	0.79817	3
Hard wood	0.93866	1
Wheat straw	0.00000	5
Sugarcane bagasse	0.93765	2
Corn cob	0.61414	4

Table 8 exhibits the final evaluation score (ASi) and ranking assigned to each bioresource through the application of the EDAS method. The ASi serves as a comprehensive measure, encompassing all pertinent factors and their respective weights in the assessment process. Hardwood emerges as the frontrunner with an ASi of 0.93866, clinching the top position (1). This underscores hardwood's superiority among the alternatives, stemming from its commendable performance across cellulose, hemicellulose, volatile matter, moisture content, and ash content. Sugarcane bagasse closely trails behind with an ASi of 0.93765, securing the second spot. This suggests that sugarcane bagasse exhibits similarly promising attributes, positioning it as a formidable competitor. Sunflower shells achieve an ASi of 0.79817, securing the third position. Despite slightly trailing hardwood and sugarcane bagasse, sunflower shells still demonstrate substantial potential across various applications. Corn cobs attain an ASi of 0.61414, earning them the fourth rank. While their performance may not match the top-ranked alternatives, corn cobs present notable qualities worthy of consideration. Wheat straw, with an ASi of 0.00000, occupies the fifth and final rank. This starkly indicates that wheat straw's performance significantly lags behind the other alternatives, suggesting limited suitability for intended purposes.

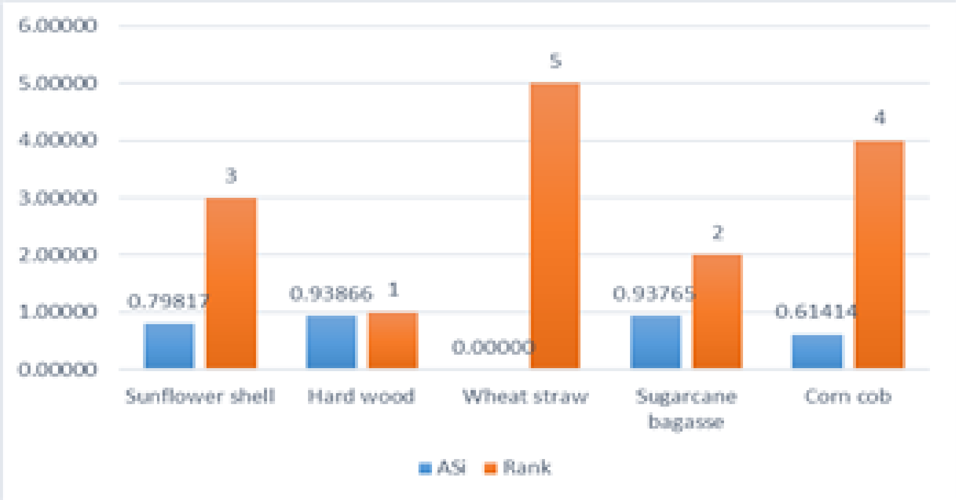

FIGURE 3. Bioresource Ranking based on ASi

Figure 3 depicts the final appraisal score (ASi) and ranking assigned to each bioresource using the EDAS method. The ASi serves as a comprehensive metric, taking into account all relevant factors and their respective importance in the evaluation process. Hardwood emerges as the top performer, securing the leading position. This underscores hardwood's superiority among the alternatives, attributed to its commendable performance across various parameters. Sugarcane bagasse closely follows, claiming the second position. This indicates that sugarcane bagasse possesses similarly promising characteristics, positioning it as a strong contender. Sunflower shells achieve a respectable ranking, securing the third position. Despite trailing hardwood and sugarcane bagasse slightly, sunflower shells still exhibit significant potential across diverse applications. Corn cobs place fourth. While they may not match the top-ranked alternatives, corn cobs present noteworthy attributes worthy of consideration. Wheat straw occupies the fifth and final rank. This starkly indicates that wheat straw's performance falls significantly behind the other alternatives, suggesting limited suitability for intended applications.

4. CONCLUSION

The examination of pyrolysis material selection through the EDAS multi-criteria decision-making method has provided significant insights into the suitability of various bioresources for pyrolysis applications. By considering critical factors such as cellulose, hemicellulose, volatile matter, moisture content, and ash content, the EDAS method established a comprehensive evaluation framework. The analysis unveiled hardwood as the most promising feedstock, securing the top rank with an impressive ASi score of 0.93866. Its exceptional performance across multiple parameters, including elevated cellulose and volatile matter contents alongside low moisture and ash levels, positions hardwood as an appealing choice for pyrolysis processes. Sugarcane bagasse closely trailed behind, attaining the second rank with an ASi of 0.93765, showcasing its potential as a viable alternative due to its advantageous composition. Sunflower shells and corn cobs secured the third and fourth positions, respectively, displaying moderate positive deviations from the average solution. Although these bioresources may not surpass hardwood and sugarcane bagasse, their distinct characteristics—such as the high cellulose content in sunflower shells and the low ash content in corn cobs—hint at potential applications in specific pyrolysis contexts. Conversely, wheat straw ranked last, with an ASi of 0.00000, indicating its limited suitability as a pyrolysis feedstock. Its elevated moisture content and relatively low volatile matter content contributed to its underperformance in the evaluation. Nonetheless, it's important to acknowledge that wheat straw might still find utility in other biomass conversion processes or in co-pyrolysis scenarios, where its properties could complement those of other feedstocks. The EDAS method's capability to handle both positive and negative deviations from the average solution enabled a comprehensive evaluation, revealing the strengths and weaknesses of each bioresource. This methodology facilitated a nuanced comprehension of the trade-offs involved, guiding decision-making processes for the selection of appropriate feedstocks based on specific process requirements and desired product characteristics. The research highlights the effectiveness of the EDAS method in assessing material selection for pyrolysis, providing a structured and transparent approach to tackle complex multi-criteria decision-making challenges. By incorporating relevant factors and utilizing the method's simplicity and computational efficiency, researchers and industry professionals can make well-informed decisions to optimize pyrolysis processes and contribute to the sustainable conversion of biomass resources into valuable products.

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